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USSR Report

CHEMISTRY

(FOUO 1/81)

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CHEMICAL INDUSTRY

COKING BY-PRODUCT INDUSTRY URGED TO GREATER EFFORTS

Moscow KOKS I KHIMIYA in Russian No 3, Mar 80 pp 2-3

[Editorial: "Shockwork in the Decisive Year of the Five-Year Plan"]

[Text] The November (1979) CPSU Central Committee plenum and the USSR Supreme Soviet second session, summed up results for 1979 and examined and confirmed the national economic plan for 1980, the final year of the 10th Five-Year Plan. The main indicators for 1979 are characterized by an increase in the scales of social production, a rise in its technical level, and a further upsurge in the people's well-being. During 1979, about 1,000 major state industrial enterprises were commissioned, including the Sayano-Shushenskaya GES, the Kurskaya, Chernobylskaya and Armyanskaya nuclear power stations, the Pavlodar and Lisichansk oil refineries, the Kamskiy Automobile Plant, the Vologodon "Atommash" Plant, and many others. Housing construction took place on a large scale and more than 102 million square meters of residential premises were brought into use.

More than 180 million rubles were assimilated in the construction of projects for the coking by-product industry, including about 140 million rubles for construction and installation work. Coking Battery No 10 has been commissioned at the coking by-production facility at the Cherepovets Metallurgical Plant, and the capacity of the coal-preparation factory has been increased by 700,000 tons; a powerful coking battery with USTK [expansion unknown] and a complete covered coal warehouse with wagon tipplers have been commissioned at the Kemerovo Coking By-product Plant; the construction of Coal-Preparation Factory No 2 at the coking by-product production facility at the Karaganda Metallurgical Combine has been completed; Coking Battery No 4 at the Krivoy Rog Coking By-Product Plant and Coking Battery No 1 at the Makeyevsk Coking By-Product Plant have been commissioned.

At the Avdeyevsk Coking By-Product Plant, construction of the powerful Coking Battery No 9 is nearing completion. Construction continues at the Altay Coking By-product Plant where more than 100 million rubles have been assimilated on construction projects since the start of construction, and a modern housing settlement, a school, and a kindergarten and other social and cultural projects have been constructed. On the plant site installation work is underway on the first section of a TETs to be commissioned this year, and Coking Battery No 1 complete with corresponding workshops.

Unfortunately, last year, the construction organizations of the USSR Ministry of Construction of Heavy Industry Enterprises and the USSR Ministry of Construction did not fully assimilate the capital investment allotted for many project construction sites for the coking by-product industry.

In 1979 the collectives of most enterprises labored intensely under conditions of serious interruptions in the delivery of coals for coking. Coking by-product production facilities at the Nizhniy Tagil, Orsk-Khalilov and Karaganda metallurgical combines, the Cherepovets and Rustavi metallurgical plants, the Moscow Coke and Gas Plant, and the Gorlovsk, Donetsk, Yenakiyevsk, Yasinovo, Dnepropetrovsk and Dneprodzerzhinsk coking by-product plants operated well. Certain plants, both in the East and in the Ukraine, did not fulfill plans for coke production, some because of the untimely commissioning of batteries through the fault of the construction workers, and others because of their own internal reasons. Without doubt, 1979 was a very difficult and far from favorable year for the country's coking by-product workers, particularly during the winter period. Under these difficult conditions the managers of coking by-product production facilities and coking by-product plants, the chiefs of shops, and together with them the enterprise collectives, carried out inspections. Not all managers succeeded in insuring normal operation of the enterprise.

The collective at the coking by-product production facility at the Nizhniy Tagil Metallurgical Combine imeni V. I. Lenin (managers A. N. Berkutov and A. A. Kern), for example, came through this test with flying colors and are continuing to operate rhythmically. And the Tagil people have coking ovens, and all their other equipment too, that have been in operation for 40 years. Year after year the collectives of the Moscow Coking and Gas Plant, the Dnepropetrovsk Coking By-Product Plant, which recently celebrated its 50th anniversary, the Yasinovo plant and a number of other coking by-product plants in the Ukraine, operate rhythmically and smoothly.

Why is it that these enterprises operate so well? There can be but one answer: the managers of these enterprises together with the engineering and technical personnel and the workers under the leadership of the party organizations strictly guard and multiply the fine traditions, organize work in full accord with the rules of technical operation, instill a sense of irreconcilability toward shortcomings, and constantly strengthen labor and technological discipline.

One of the most important conditions for the normal operation of a shop and of an enterprise as a whole is, on the one hand, a high level of exploitation of equipment, and on the other, the strictest observance by the main mechanical and power services of planned preventive maintenance and provision of the shops with spares and replacement equipment. This makes it possible to eliminate the incidence of accidents and rush work. The paramount concern of the plant director, and the chief of the coking by-product production facility should be every possible strengthening of the repair base and the creation of mobile plant repair organizations to carry out operational maintenance on equipment.

The most important state obligation of the chief engineer is constant organizational work for undeviating observance of the rules of technical exploitation at all production sectors without exception. Where all these conditions are observed there is no slack discipline or an irresponsible attitude toward work entrusted, leading to breakdowns and disruption of the production rhythm. High labor discipline is the guarantee of fulfillment of the state plan.

The size of an enterprise does not determine its activity. Success in the entire business is insured by skillful organization work by managers. As an example, we can cite the coking by-product production facility at the Cherepovets Metallurgical Plant (managers N. Ye. Temkin and Ye. N. Mishin)--one of the largest modern coking by-product enterprises in the country. Two large-capacity coal-preparation factories, two coking shops with USTK, a pitch and coking production facility, and shops for the recovery and reprocessing of chemical products from coking--this is huge even by today's scales of production! Nevertheless, year after year, the people at Cherepovets overfulfill plans for output and take places of honor in All-Union socialist competition, despite the fact that throughout recent years the coking by-product production facility has been undergoing construction and expansion. The collectives and managers of many other coking by-product production facilities and plants also deserve a good word.

Unfortunately, during 1979 enterprises such as the coking by-product production facility at the West Siberian Metallurgical Plant (managers V. K. Kachayev and A. N. Patrushev) and the Kemerovo Coking By-product Plant (managers V. A. Shestakov and A. M. Denisov), which is the bearer of two Orders, did not work so well and have never before this been among the lagging enterprises. It is to be hoped that the Kemerovskaya oblast organizations and the USSR Ministry of Ferrous Metallurgy's Soyuzmetallurgprom [All-Union Industrial Association of Metallurgical Enterprises for Capital Construction] will aid these two major enterprises of the oblast once again to become leading enterprises. The unsatisfactory work of the Avdeyevsk, Zaporozhye and certain other coking by-product plants in the Ukraine has been noted earlier on the pages of this journal. The managers of these enterprises still have to do a great deal in order to set up rhythmic operation and remove themselves from among the lagging enterprises.

In recent years there has been a decrease in attention to the chemical shops at coking by-product enterprises. As a result, the technical and economic indicators for chemical production facilities have fallen sharply, and this undermines the economic system of the enterprises and harms the national economy. High losses of benzene during its recovery from coke-oven gas is permitted at coking by-product production facilities at the Novolipetsk and West Siberian metallurgical plants, the Karaganda Metallurgical Combine, and the Kemerovo, Dneprodzerzhinsk, Avdeyevsk, and Krivoy Rog and other plants. Some plants are not fulfilling plans for the production of ammonium sulfate; the recovery of phenol from effluent, pyridine bases and naphthalene has deteriorated. This is happening mainly because of violations of technological conditions and equipment malfunctions. It is no longer possible to accept such shortcomings; a decisive struggle must be waged against production losses.

In his speech at the plenum, CPSU Central Committee General Secretary comrade L. I. Brezhnev said: "It is essential to implement with redoubled and tripled energy the party's course toward improving efficiency and quality. There is no alternative to this course, and it should be undeviatingly followed during the 11th Five-Year Plan." This party directive applies fully to all sections in coking by-product production. We are obliged at all levels of management to apply, immediately, measures for the more efficient utilization of fixed production capital and the newly commissioned capacities of coking batteries and coal-preparation factories (this applies primarily to the Avdeyevsk and Kemerovo coking by-product plants and the coking by-product production facility at the West Siberian Metallurgical Plant), to recover all the precious products of coking from coke-oven gas, not to permit losses in the reprocessing of resins, and to set things to right in the operation of dephenolization installations. Particular attention should be given to raising the level of the organizational activity of shop and section chiefs, foremen, and enterprise managers. The main task for 1980 is that of striving to achieve fulfillment of production plans by all coking by-product enterprises, and the plan for the commissioning of new capacities. Resolution of this task will also make it possible to gradually overcome all other shortcomings in the activity of this subsector. The problem of the labor force in the coking by-product industry is now more acute than ever before. It is impossible to be reconciled with losses of workers to other sectors of industry. Emergency measures are needed to insure the creation of stable labor forces of specialists at all coking by-product enterprises. The question also arises of how specialized training and instruction for (particularly young) directors and chief engineers can be fitted to the art of enterprise management.

We often say that an economic manager is a trusted person of the party and state. At the same time it is difficult to imagine successful work in a manager who acts apart from the party, trade union and Komsomol organizations. It is only in close contact with the public organizations of the plant and shop that a manager can count on the successful implementation of all measures aimed at strengthening technological and labor discipline and at rhythmic work.

The year of 1980 should become a turning point in the coking by-product industry. It is necessary to mobilize all the available efforts of engineering and technical workers and laborers to strict fulfillment of the rules of technical exploitation, without which it is impossible to count on success; to strengthen maintenance service and carry out repairs on equipment in full accord with the schedules for planned preventive maintenance; to improve technological discipline and not to operate malfunctioning equipment; to reestablish the refractory worker crews on the coking ovens and to carry out systematic preventive maintenance on the oven inwalls; and to observe strictly the cyclic shutdowns, using them for maintenance work and setting the ovens in good order.

Instilling a sense of responsibility for the business entrusted should hold the constant attention of the manager. This work is difficult but essential. The plant director and the chief engineer and their deputies should be in the shops more often during the changing of the shifts, investigate omissions in the work, and offer specific help to the shop chief. Only systematic help for the lagging shop will enable it to overcome the hitches. For this, it is essential to know precisely what kind of help is really needed, work out a program, determine the persons responsible, and give the order and undeviatingly implement it. The plan for 1980--the final year of the 10th Five-Year Plan--is an important link in fulfilling the decisions of the 25th CPSU Congress. The main directions in the activity of all collectives should be to develop socialist competition to fulfill the state plan for the production of coke and chemical products set for 1980, consistently maintain conditions of thrift and rational utilization of material and financial resources, struggle to strengthen labor and technological discipline, and raise labor productivity.

The coking by-product industry faces great tasks during 1980 in the field of technical progress, the introduction of new equipment, leading technology, the mechanization and automation of production processes, and the fulfillment of scientific research and test and design work, including the construction of an installation for heat-preparation of the coal charge before coking at the coking by-product production facility at the West Siberian Metallurgical Plant; project planning by Giprokoks [State Institute for the Planning of Establishments of the By-Product Coke Industry] for an installation for the production of molded coke for the Dnepropetrovsk coking by-product plant; work on partial briquetting of the coal charge before coking and obtaining nonoven types of coke for sintering, ferroalloy, casting and chemical production; and improving processes and designing apparatuses for the recovery and processing of chemical products from coking.

Much attention will be given to capital construction. In 1980, provision has been made for the construction and commissioning of a coking battery at the Altay Coking By-Product Plant, the completion of work on starting up coking battery complexes at the Zaparozhye and Avdeyevsk coking by-product plants and the Chelyabinsk Metallurgical Plant, and also advance work for reconstruction of batteries at the coking by-product production facilities at the Magnitogorsk Metallurgical Combine, the Chelyabinsk Metallurgical Plant, the Zaparozhye Coking By-Product Plant and the pitch and coking installation at the Cherepovets Metallurgical Plant.

At the November Plenum comrade L. I. Brezhnev said: "At the center of our efforts should be the mobilization of the workers to fulfill the tasks of the final year of the Five-Year Plan." In response to the decision of the CPSU Central Committee plenum and the USSR Supreme Soviet second session, Soviet workers in the coking by-product industry will direct all their efforts and energy during 1980 to shockwork to fulfill the plan of the final year of the 10th Five-Year Plan.

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CHEMICAL INDUSTRY IN 1980

Moscow KHIMICHESKAYA PROMYSHLENNOST' in Russian No 6, Jun 80 pp 323-327

[Article by L. A. Kostandov, ministry of chemical industry: "Performance Should be Improved Compared With the Past"]

[Text] The present year 1980 is an important link in the implementation of tasks of the 10th Five-Year Plan as a whole. At the November (1979) Plenum of the CPSU Central Committee L. I. Brezhnev pointed out that 1980 is "not only the final year of the current five-year plan period but also the base on which the next five-year plan is substructured. It is a year of active preparations for the 26th Party Congress. The work accomplished and the tasks for 1980 should be assessed from precisely these positions."

In the first four years of the current five-year plan period, as was pointed out at the Plenum, major advances have been made in solving the problems of socio-economic development of the Soviet Union as formulated by the 25th Party Congress. A major contribution to the cause of further strengthening of the nation's economy has been made by chemical industry workers.

During those four years the industry's enterprises produced output that was 27.53 million rubles greater than during the same period of the preceding five-year plan. The national economy was provided with an additional 81.8 million tons of fertilizers, including 35.4 million tons of nitrogenous fertilizers, 29.5 million tons of phosphoric fertilizers, and 21.1 million tons of potassic fertilizers, as well as 568,300 tons of chemical crop protectants, 3,657,000 tons of plastics and synthetic resins, 1,198,000 tons of chemical fibers, and 2,800 million rubles worth of consumer goods and cultural and economic goods. The variety of chemical output was markedly broadened and its quality improved.

The 10th Five-Year Plan period has been a period of rise of various new types of large-scale chemical production, including mineral fertilizers and the corresponding raw materials. Chemical-industry workers and allied collectives were warmly congratulated by General Secretary of the CPSU Central Committee L. I. Brezhnev for their notable accomplishment in putting into operation the most important large-scale chemical industry facilities. L. I. Brezhnev's words of welcome were addressed to participants in the construction and preterm activation of large-scale complex fertilizer production facilities at the Almalyk and Cherepovets chemical plants, the Voskresensk Subdivision of Minudobreniya [Mineral Fertilizers], the Novomoskovsk Subdivision of Azot [Nitrogen], acrylic acid nitrile facilities at the Saratov Subdivision of "Nitron," and other major new construction projects of chemical industry.

Even during the unfavorable previous year, despite various objective reasons which complicated the branch's performance as a whole, many pacesetting collectives succeeded in so organizing the activities of their enterprises that they not only fulfilled but also overfulfilled plan-set tasks and adopted socialist pledges. These included the Plastpolimer NPO [Nongovernmental Organization for Polymer Plastics] in Okhta, the Shostkinskoye "Svema," the Sterlitamak "Soda," the Lithuanian Ltivbytkhim, and other production associations. The best of these--the crews of 18 enterprises of the branch--were rewarded of their outstanding performance in 1979 with Challenge Red Banners of the CPSU Central Committee, the USSR Council of Ministers, the All-Union Central Council of Trade Unions, and the Komsomol Central Committee, and 15 of these were listed on the All-Union Roll of Honor at the All-Union Exposition of Achievements of the USSR Economy.

However, our accomplishments could have been greater had not it been for major shortcomings and interruptions in the branch's performance. In 1979 the output of the enterprises of the Ministry of Chemical Industry fell short of the goals by more than 9 million tons of mineral fertilizers, 326,000 tons of plastics and synthetic resins, 88,000 tons of chemical fibers, and 87,000 tons of paints and lacquers. Moreover, the branch's workers failed to satisfy the demand for consumer goods. The underfulfillment of the plan as regards the principal types of production has resulted in underfulfillment of targets for the volume of sales of output, profits, production cost, and labor productivity. Of course, the past year was extremely unfavorable and difficult: the severe winter and the shortages of heat and energy complicated the work of the enterprises. The branch found itself in a difficult situation owing to stoppages in the supply of raw materials and gas as well as in the deliveries of freightcars. However, the lag of chemical industry cannot be explained by objective causes alone. Much depends on major internal shortcomings, poor work discipline and technological discipline, and an insufficiently high level of organizational work.

The timely and just criticism addressed to the Ministry of Chemical Industry by General Secretary of the CPSU Central Committee L. I. Brezhnev at the November (1979) Plenum of the CPSU Central Committee, obligates us to critically assess the Ministry's performance last year. The causes that engendered such a major lagging of our branch behind the outlined goals must be most responsibly analyzed.

A thorough analysis of all the causes of unsatisfactory performance of the branch last year revealed several principal causes that prevented the branch's workers from operating smoothly and fulfilling all the state tasks. These causes are, chiefly, the unsatisfactory rate of construction of new projects and utilization of new productive capacities, violations of rules for the maintenance of technological equipment, unsatisfactory organization of repair services, inefficient use of raw materials, ineffective performance of scientific research institutes, and the occasionally-encountered formalistic attitude toward socialist labor competition.

But it cannot be said that the situation in our branch is all bad, that there are no accomplishments. Of course, they exist. Last year much as been done to put new capacities into operation, such as, e.g., 14 ammonia production units with a capacity of 450,000 tons each and 18 mineral fertilizer production units. In addition major facilities for the production of polyethylene, phtalic anhydride, and raw materials for plastics have been put into operation. Various steps have been taken to speed up the construction of projects built on the basis of compensation agreements.

Nevertheless the targets set for the year were largely underfulfilled. Of the scheduled new 354 production units, 186 were not put into operation, i.e., nearly one-half, which markedly complicated the targeted development of the branch and led to imbalance in the supply of raw materials to the newly activated facilities.

To some extent the underfulfillment of the construction plan was affected by shortcomings in the performance of subcontractors and hence also by a marked lag in construction and installation operations. But that was only one reason.

The fate of chemical-industry projects largely depends on the client himself--the Ministry of Chemical Industry. Our design organizations often delay providing blueprints and tolerate errors, which in its turn entails design revisions. Certain enterprises often disregard the deadlines for equipment deliveries, and in some instances we encounter facts of unjustified increases in cost estimates of construction and an uncoordinated activation of discrete facilities and supply of raw materials for them. All this has resulted in the failure to complete one-third of the projects through our fault.

The branch's performance is also adversely affected by the slow utilization of production capacities. Thus, of the 238 newly operating production units as of 1 January 1980, 40 are being utilized behind schedule and some of their capacities have long remained underutilized. As a result, in 1979 production for the national economy fell short by about 220 million rubles.

At the same time, an analysis of the progress made in utilizing production capacities, conducted by the Administration for Science and Technology, jointly with the Orgkhim Trust, demonstrated the feasibility of preterm utilization of these capacities. In particular, this is feasible at the Novomoskovsk and Novgorod subdivisions of "Azot," at the Samarkand Superphosphate Plant, and at the Cherepovets and Perm' chemical plants.

The slow utilization of new capacities is often due to shortage of skilled personnel and gross violations of rules for the maintenance of technological equipment. This results in prolonged stoppages of not just discrete facilities but entire shops.

L. I. Brezhnev said that, "At the present stage the price of stoppages, shoddy work, and errors is totally different. A half-hour's stoppage by a man with a shovel is one thing, but a half-hour stoppage by the same man when operating a heavy-duty excavating machine, a combine, or a tower crane, is another. There is simply no comparison."

Thus, at the Bereznikovskiy Nitrogen Fertilizers Plant, the ammonia facility stood idle for 200 days in 1979, and thus the output of ammonia fell short by 200,000 tons or by 800,000 tons in terms of mineral fertilizers. At the Nitrogen Fertilizers Dorogobuzh Plant, the output of mineral fertilizers fell short by 600,000 solely owing to the breakdown of a turbocompressor, also in 1979.

There occur frequent instances of violations of equipment maintenance rules at the Leningrad "Pigment" NPO, and at the Balakovskiy, Keday, Konstantinovskiy, Chardzhou, and Uvarovsk chemical plants. Owing to such violations, more than 45 percent of the entire pool of electrical motors has to be repaired annually at the enterprises of the "Fosfor" All-Union Association.

Clearly, each enterprise should systematically monitor the level of equipment maintenance and take prompt and needed measures to raise it. All this should be of unflagging concern to the heads of the All-Union industrial associations.

A well-organized repair service is highly important to a highly productive performance of any enterprise. Much work has been done in the branch to develop interplant repair organizations, which last year assisted in carrying out 449 shutdown repair operations. Sometimes, however, the repair services of enterprises are merely transferred to the jurisdiction of these organizations, without even adequate specialization in types of operations.

A major oversight in the organization of intraplant repair services has been the dispersal of repairmen among technological shops and types of production. As of 1 August 1979 the basic shops accounted for 49.5 percent of fitters and 46.8 percent of electricians for equipment repair. As a result, the level of the centralization and thus also of the specialization of plant repair services proved to be totally inadequate given the existing manpower shortage. It is highly important that the work of repairmen be evaluated according to quality rather than volume of operations performed. After all, only a smooth operation and satisfactory state of equipment can serve as the criterions for assessing the performance of repair services.

The quality of repair largely depends on the supplies of spare parts; their shortage affects the performance of the entire branch. Here, too, there exists unexploited potential. Thus, certain managers disperse among many enterprises the machine tools allocated for the production of spare parts, instead of concentrating these tools at the appropriate bases. It happens fairly often that the workers of supply divisions poorly utilize the limited funds assigned to them. For example, at the Soyuzosnovkhim All-Union Association the funds for chemical equipment were utilized only 70 percent in 1979, and at the Soyuzkhimvolokno All-Union Association, they were utilized even less--66 percent. In this matter greater on-the-spot personal initiative is needed.

L. I. Brezhnev pointed out in his speech during the encounter with voters in Baumansky Rayon of Moscow: "One thing is clear: failure looms wherever people sit with hands folded and await instructions from higher up on every matter. Conversely, if people boldly tackle tasks and display initiative or support practical undertakings, their success is assured."

Many heads of enterprises which underfulfilled their targets refer to shortages and uneven supplies of raw materials. Yes, for a number of years the branch has been experiencing major supply problems. Chemical industry periodically receives inadequate supplies of such materials as zinc metal, pyrite, sawdust, viscose cellulose, and cardboard. All this prevents a full utilization of existing and newly introduced production capacities. Nevertheless a thorough study of this problem shows that among us there exists an unexploited potential for a more efficient and economical use of raw materials. But proper attention is far from always paid to this problem.

It is no secret that a shortage of caustic soda had arisen more than 10 years ago. But at Sumgait that soda has been used in lieu of milk of lime in the production of epichlorohydrin since 1975, while calcined soda has been used in lieu of limestone since 1979. This can be in no way tolerated.

A large quantity of caustic soda is used for water treatment by the ion exchange method in ammonia and polyethylene production. This year, e.g., plans exist for using for this purpose 60,000-65,000 tons of alkali in ammonia production. And yet the Scientific Research Institute of Plastics has developed a water treatment method based on the use of electroinite membranes which serves to markedly reduce or even completely eliminate the use of alkali and sulfuric acid as well as to reduce the consumption of electrical power and the liquid waste byproduct. As early as this year it is necessary to test this method at one of the branch's enterprises.

So far, chemical industry has been wasting a lot of raw materials. During the first three years of the 10th Five-Year Plan period, for the Ministry of Chemical Industry as a whole the excess consumption of sulfuric acid reached 550,000 tons; apatite concentrate, 495,000 tons; ammonia, 315,000 tons; caustic soda, 155,000 tons; and sulfur, 60,000 tons. Instances of spoilage and losses of raw and other materials still persist, along with the practice of planning different quotas of raw materials consumption for enterprises using the same technology and producing the same chemicals. The standards for the consumption of the principal types of raw materials at all enterprises should be raised to the level achieved at the pacesetting enterprises. Then we can produce additional hundreds of thousands of tons of mineral fertilizers by saving sulfuric acid, apatite concentrate, and ammonia.

This country is known to have the world's largest fuel and power complex. But, as stressed by L. I. Brezhnev at the November (1979) Plenum of the CPSU Central Committee, "whatever the rate at which we develop power industry, conservation of heat and energy will continue to be a most important state-wide task."

Last year chemical industry workers took part in the All-Union Public Inspection dealing with efficient utilization of material resources. In the course of the Inspection 106,193 proposals for conserving fuel, power, and material resources were submitted. Of these, 85,882 were introduced, producing conditional annual savings of 142.2 million rubles. However, repeated inspection of the performance of enterprises in 1979 showed that their internal potential for saving fuel and power is far from always and everywhere adequately utilized. For example, of the 52 production facilities inspected, 14 even operated without setting targets for reducing the consumption quotas for these resources. Instances of considerable losses of fuel during its transport and storage and inadequate use of secondary resources also were uncovered.

The best indicators of fuel and power savings last year were achieved by the Dzhambul Khimprom, Novomoskovsk Azot, Yavorovskoye Sera, and Beloruskaliy production associations. Thirty enterprises failed to cope with the consumption quotas set for them.

Another source for improving the branch's supply situation is the mobilization of existing inventory surpluses. Unfortunately, these surpluses are growing instead of diminishing. They are particularly high at the enterprises of the All-Union Soyuzkhlor, Soyuzosnovkhim, Soyuzazot, and Soyuzkhimvolokno.

At many enterprises, freightcar loading and, particularly, unloading operations are improperly organized. As a result, freightcar demurrage at enterprises of the Ministry of Chemical Industry exceeded the standard by 2.5 hours on the average, and even more at certain plants. For example, at the enterprises of the All-Union Association Soyuzanilprom freightcar demurrage averages 10 hours. A particularly intolerable situation in this respect has arisen, e.g., at the Aktyubinsk Chemical Plant, the Samarkand Superphosphate Plant, the Kemerovo Subdivision of Azot, the Dzhambul Subdivision of Khimprom, and certain others. Through the fault of these enterprises, 500 freightcars daily experienced delays in unloading: this figure accounts for more than one half of all freightcars experiencing such delays at the enterprises of the Ministry of Chemical Industry.

At the same time, experience of the leading crews demonstrates that these losses can be avoided. Great vistas in this respect are opened by the CPSU Central Committee-approved experience gained by industrial enterprises of Chelyabinskaya Oblast and subdivisions of the South Ural Railroad in reducing transloading delays of freightcars.

One more factor hobbling the branch's performance should be mentioned: the unsatisfactory activity of our institutes and enterprises as regards introducing new equipment. The related plans are consistently underfulfilled both owing to certain objective causes and to the low quality of the scientific research performed. This in its turn results in considerable additional material expenditures. Consider one example. The All-Union Scientific Research Institute of Synthetic Fibers spent more than 5 million rubles on developing a technology for the production of polyvinyl chloride staple fibers, but the quality of the research performed was so low that this innovation has not so far been introduced. To perfect this technique, the All-Union Soyuzkhimvolokno Association had to spend an additional 13.5 million rubles, i.e., nearly three times as much as the cost of the original project. Three years ago the Collegium of the Ministry of Chemical Industry had uncovered major shortcomings in the planning of R&D work, causing the scientific research institutes to dissipate their efforts on minor topics or on projects which subsequently found no practical application.

The performance of the chemical industry in 1979 was the subject of discussion at a general conference by the Collegium of the Ministry of Chemical Industry and the Presidium of the Central Committee of the branch's trade union, at which the existing shortcomings were thoroughly analyzed and measures to eliminate them as soon as possible and to uncover and exploit latent potential were outlined.

What matters most is that at present the Party sets the goals for the enterprise collectives--this is the fullest and most effective means of utilizing the mighty economic and scientific-technical potential created in this country and eliminating any obstacles to a maximally productive performance.

In the light of the decisions of the November (1979) Plenum of the CPSU Central Committee and the postulates and conclusions of the speeches of L. I. Brezhnev, chemical industry workers face great and responsible tasks in 1980. In this final year of the five-year plan we should liquidate the lag and do everything to fulfill the State plan and the adopted socialist pledges. An extremely challenging task lies ahead.

The volume of gross output will increase by 10.7 percent compared with 1979. The output of mineral fertilizers will increase by 25.5 percent; this includes: nitrogenous fertilizers, by 22.6 percent; phosphoric, by 24.7 percent; and potassic, by 42.4 percent. The output of synthetic ammonia will increase by 28.5 percent; caustic soda, by 8.9 percent; and chemical fibers and threads, by 13.7 percent. The production of consumer goods is expected to develop at a spearheading rate--by 16.1 percent (of which the output of synthetic detergents alone, by 34.7 percent), compared with the slated 10.7 percent increase in chemical industry output as a whole.

The production of synthetic detergents should provide an instructive example to all of us. As everyone remembers well, late last year there arose an acute shortage of these detergents, largely through the fault of chemical industry workers. For this we were justly criticized at the November Plenum of the CPSU Central Committee and in numerous press comments.

This year, now that the appropriate associations and enterprises have properly tackled this problem, the situation has begun to improve. The January and February plans for the output of the detergents have been fulfilled, although disruptions in the supply of raw materials to the enterprises still occur.

The plan for the output of consumer goods was examined last January and February by the Collegium of the Ministry of Chemical Industry. The attention of the heads of the functional administrations and agencies of the Ministry as well as of the All-Union production associations has been focused on increasing personal responsibility for the production of consumer goods and the related raw materials. The Collegium assigned the heads of the All-Union production associations the task of finding the necessary resources for producing an additional 60-80 million rubles of these goods this year.

Labor productivity is expected to rise 8 percent this year, owing to a rise in the technological level of production, the mechanization of labor-consuming manual operations, and improvements in the utilization of work time. Meticulour work with those who display lack of discipline and improper behavior is needed.

It is necessary to work better with people, to pay more attention to their needs and, above all, not to overlook even one initiative, one labor-saving suggestion. Then, doubtless, the number of our production pacesetters will be much greater.

In addition to acceleration of the growth rate of production it is necessary to further work to uncover the exploit more completely the latent production potential with the object of increasing the output of the principal chemicals, assuring the fulfillment of the plan for capital construction, activating new production capacities and accelerating their utilization.

The plans for this year, e.g., provide for putting into operation capacities for the production of 10.97 million tons of mineral fertilizers, 1.55 million tons of ammonia, 1.89 million tons of sulfuric acid, and 1.16 million tons of plastics and synthetic resins. They also provide for releasing for occupancy 1,446,000 sq m of dwelling area, building institutions with 14,200 vacancies for children, increasing the number of hospital beds by 1,610, and completing the construction of various other civic and communal facilities.

As adopted by the CPSU Central Committee, the USSR Council of Ministers, and the All-Union Central Council of Trade Unions, the Decree "On Further Consolidation of Labor Discipline and Reduction of Personnel Turnover in the National Economy" points out: Under present-day conditions, as the scale of production increases, economic relations grow more complex, and scientific and technical progress increases, there is a corresponding increase in the importance of every minute worked, of a strict observance of operating rules, of the formation of stable personnel at every sector of production."

Hence we face a major task in raising the general discipline and sophistication of production. Special attention must be given to working with people, providing them with better working conditions, and forming stable and smoothly-coordinated labor collectives.

L. I. Brezhnev said that the fulfillment of the challenging tasks for 1980 "requires creating a highly demanding atmosphere, an atmosphere of well-organized work and creative attitude toward work in every sector of the national economy, in every cell of production. To this end it is necessary to exploit more fully the potential of socialist labor competition by eradicating shortcomings in its organization and eliminating elements of formalism. It is necessary to strengthen the attention paid to the educational functions of labor competition and of the movement for a communist attitude toward work."

Socialist labor competition, which has absorbed the enormously rich traditions of the communist subbotniks [voluntary Saturday workers] and of the shock-worker movement of the first few five-year plan periods, provide boundless possibilities for manifesting creative activity, initiative, talent, and ability by the toilers within our branch.

We have quite a few workers of whom we can be justly proud. Many of them accomplished valuable feats and undertakings. More than 6,000 persons already have fulfilled their personal five-year targets and started to fulfill the 11th Five-Year Plan ahead of schedule. And Galina Dmitriyevna Usatenko, twisting machine operator at the Berdyansk Glass Fibers Plant, already has fulfilled two five-year plans and this coming November intends to fulfill a third.

The entire country has heard of the Delegate to the 25th CPSU Congress T. N. Kruzina, a machine operator at the Kursk Subdivision of "Khimvolokno," A. D. Magnitskaya, an extruder operator at the Vladimir Chemical Plant, and A. V. Posvezhinnyy, a machine operator at the Novomoskovsk Subdivision of Azot. For their sacrificial labor they were awarded in 1979 the honored title of USSR State Prize Winner.

Chemical industry workers take an active part in the nationwide socialist competition for streamlining production, improving quality of work, and fulfilling ahead of schedule the plans for 1980 and for the five-year period as a whole.

The workers of the OKhta Plastomer NPO, responding by deeds to the CPSU Central Committee's Decree "On the 110th Anniversary of the Birth of V. I. Lenin," resolved to complete the five-year plan for volume of output by 1 September 1980 and to produce an additional 25 million rubles of output by year's end.

The personnel of the Nevinnomyssk Subdivision of Azot pledged themselves to exceed their output target by 30,000 tons of mineral fertilizers, of which 7,500 tons by the 110th anniversary of the birth of V. I. Lenin, by such means as intensification of production, more effective use of production capacities, and prolongation of the inter-repair operating periods. What is more, on the very day of that anniversary the personnel used in their work only the resources saved.

The Voskresensk chemical plant workers pledged themselves to fulfill the five-year plan on 12 December and increase to 11.7 million rubles their overfulfillment of the five-year plan. Ambitious pledges also were adopted by the branch's other leading enterprises.

Broadly developing socialist competition for the fulfillment and overfulfillment of the 1980 plan and of the entire five-year plan period, the enterprises of the Ministry of Chemical Industry coped with the targets for the first two months of the year, and the plan for the sales of principal chemicals has been fulfilled. These accomplishments must be consolidated. As stressed by L. I. Brezhnev at the November CPSU Central Committee Plenum, our work should be chiefly geared toward orienting the enterprise crews to attainment of high quality indicators and struggle for the fulfillment of the approaching plans. It is necessary to disseminate more broadly and introduce more actively the experience gained by the pacesetting enterprises as regards the organization of labor and the management of production, as well as to strive for an unconditional fulfillment of the targets set by the 1980 plan and thereby also to lay the foundation for a successful commencement of the 11th Five-Year Plan period.

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COAL GASIFICATION

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PLASMA GASIFICATION OF COAL

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 12, Dec 80 pp 69-79

[Article by Corresponding Member of the USSR Academy of Sciences G. N. Kruzhilin]

[Text] Problems of the fuel and energy complex are now becoming especially timely. A program for development of the fuel and energy complex was called for in L. I. Brezhnev's annual report at the 25th CPSU Congress among the important complex programs, development of which acquires ever greater significance. Fuel problems occupy a significant position in it. In the decree of the general meeting of the USSR Academy of Sciences (December 1979), at which tasks of the academy in solution of timely problems of development of the national economy were discussed, the need to develop new effective methods of producing synthetic motor fuel from coal is noted. The problem of processing coal into synthetic natural gas by the promising method of plasma gasification is considered in the article of Corresponding Member of the USSR Academy of Sciences G. N. Kruzhilin, given below. The article, published in the form of a discussion, contains a number of debatable propositions. They include an estimate of the maximum capacity of LEP [Electric power transmission line], the cost of a ton of Kansk-Achinsk coal at the mine, the content of CO_2 and H_2O in the gas generated and technical and economic estimates, specifically expenditures for methane and methanol production and the cost of producing them. The editors propose to continue publication of materials of specialists in the field of power engineering about the most important problems and prospects for development of the fuel and energy complex.

The method of plasma gasification of coal is still in the stage of development both in our country and abroad. So far as is known, investigations on plasma gasification have been conducted for a number of years in Japan and the United States.* According to special reports, these investigations are also being conducted in West Germany. The initial developments in this direction were begun in 1971 in

* See: "Project for Development of Research in the Field of New Power Engineering," translated from the Japanese, 76/56070 GPNTB of the USSR: B. Douglas, "Gas From Coal," TEXTILE WORLD, No 10, 1976.

our country.* However, the technical and economic feasibility began to gain recognition, unfortunately, considerably later duc to the use of electric energy in plasmatrons in this method.

Plasma gasification can be used for the following purposes in our national economy in the future:

for gasification of Siberian coal with production of synthetic natural gas, that is, methane or liquid hydrocarbon fuel suitable for pipeline transport to the center of our country;

for gasification of coal in large steam-gas energy units which consume approximately 500-700 tons of coal per hour;

for gasification of coal and other types of solid fuels in gasifiers of relatively low capacity at machine-building, ceramics and glass enterprises and other sectors of industry which consume gas fuel in production processes.

As one can understand from the literature, comparatively small gas generators with capacity up to 4 tons/hour of coal are already being suggested in the United States for industrial use.

A diagram of a plasma gasifier is shown in Figure 1. The gasifier has the form of a furnace chamber 1, on whose walls are installed, similar to furnace burners, plasma reactors 2 with plasmatrons 3. The mixture of water vapor and oxygen is heated in the plasmatrons by means of an electric gas discharge. The plasma reactor in the diagram of Figure 1 has three plasmatrons, from which hot jets of gas emerge into its body cavity, forming a common incandescent flame. Coal dust enters reactors 2 through pipeline 4. Entering the high-temperature flow of the vapor-oxygen mixture, it is intensively gasified with formation of $CO+H_2+H_2S$ gases, which enter chamber 1 with average temperature of 1,100-1,200°C. Similar to a boiler plant, chamber 1 and the subsequent gas ducts are used to cool the gas to approximately 100°C and also to trap the slag and ash.

Due to the use of plasmatrons, the capacity of which is subject to regulation in the electric current circuit, the temperature conditions in the gasifier can be automatically maintained at a given optimum level, including that during variation of quality, inevitable during operation, of the processed, that is, initial fuel. Adequate simplicity of variation of the gasifier capacity and also starting it after planned or forced shutdowns is provided by the plasmatrons. In this sense the plasma gasifier is considerably more convenient to operate compared to a coal-dust burner. Therefore, one can confidently assume that the unit coal capacity of a plasma gasifier may not be below that of modern coal-dust burners reaching 500 tons/hr. Unit power of a plasma gasifier of 1,000-1,200 t/hr or approximately 10 million tons of coal annually, will probably be feasible with respect to mass refining of coal into high-heat methane or liquid hydrocarbon fuel and electric power of 100-150 MW will be required to power its plasmatrons. Approximately 40 reactors must be installed on the walls of the chamber of each gasifier when

*See: G. N. Kruzhilin and G. N. Khudyakov, "Plasma Gasification of Coal," Report Topics of the Second All-Union Conference on Plasma-Chemical Technology and Apparatus Construction, Vol 1, Moscow, 1977.

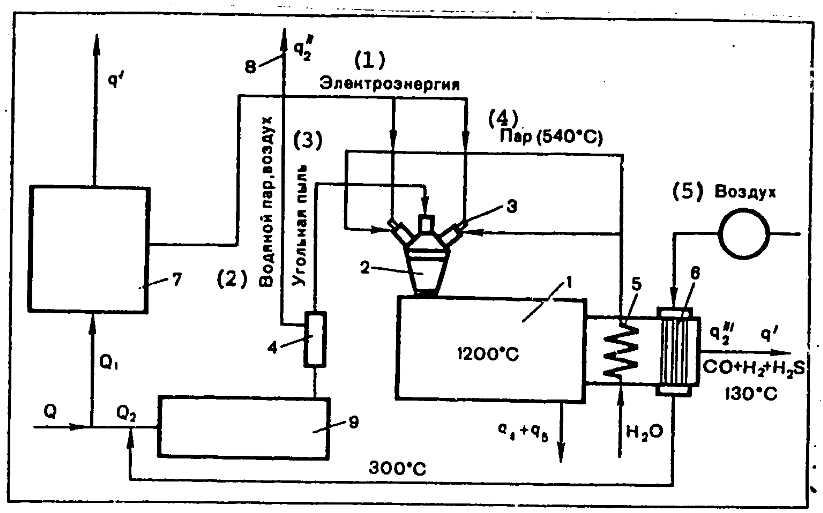

Figure 1. Diagram of Plasma Gasification of Coal: 1--gasification chamber; 2--plasma reactor; 3--plasmatron; 4--coal dust separator; 5--steam generator; 6--air heater; 7--energy installation to power plasmatrons; 8--discharge of air of dust-coal system; 9--fuel preparation

Key:

(1) Electric energy
(2) Water vapor and air
(3) Coal dust
(4) Steam
(5) Air

using plasma reactors with output of approximately 3,000 kW each. As is known, plasma reactors require periodic repair due to electrode erosion, which can be done with the presence of 40 reactors without any significant effect on the operating conditions of the gasifiers.

Naturally, the produced gas must be scrubbed of hydrogen sulfide H_2S. Therefore, it is important to note that this scrubbing is considerably easier than scrubbing of the waste gases of coal-dust boilers of sulphur dioxides SO_2 and SO_3. First, this is clear from the fact that the volume of producer gas is approximately 1/5 that of the waste gases of a boiler consisting of 4/5 nitrogen entering the boiler furnace in air with a given quantity of coal used. Second, as is known, the technology of removing hydrogen sulfide H_2S from a gas mixture has been developed and is used on a large scale at Orenburg to scrub natural gas and it is considerably simpler and more economical than methods of removing SO_2 and SO_3 from the waste gases of boiler plants.

It is these two aspects--the high unit capacity of a plasma gasifier and the technically acceptable real capability of scrubbing gas of sulphur compounds--that may determine to the greatest degree the prospects and special importance of plasma gasification with respect to mass refining of Siberian coal.

The problem of using Siberian coal to meet the fuel and energy needs of the European USSR is indeed timely to the highest degree. Until now these needs were met by development of "local" energy resources and also by a supply of large quantities of petroleum and natural gas. But, as is known, these sources of energy supply will be inadequate in the near future. But the reserves of Siberian coal are very significant. On the other hand, the distances from these coal fields to the center of the European USSR are so vast that rail transport is practically unacceptable and even more so since this is lignite--it has a calorific value below 4,000 kcal/kg and is distinguished by rather high moisture content, reaching up to 40 percent.

To illustrate this aspect of the matter, one can use the annual level of Siberian coal production as a future level, 500 million tons, equivalent in calorific value to approximately 200 million tons of petroleum. The capacity of rolling stock is aprpoximately 3,000 tons. Therefore, with the shortest possible time interval between trains of 5 minutes, a maximum of

$$\frac{365 \cdot 24 \cdot 60}{5} \cdot 3{,}000 = 300 \text{ million tons}$$

can be delivered annually over a double track railroad. Thus, two new double track railroads approximately 4,000 km long would have to be constructed to transport 500 million tons of coal annually to the center, which is of course hardly attractive economically.

With regard to this, versions with preliminary drying of coal were considered at one time. Crushing to a dust-like state would also be required. Lignite dust, having a very developed surface, is capable of spontaneous combustion upon contact with air. Because of this, special tank cars or containers with inert gas would be required to transport it. The operations of loading large amounts of coal dust and of receiving it at the points of destination are also difficult. In any case, this version was not recognized as efficient.

Naturally, there is always an alternative version of burning Siberian coal in local electric power plants with transmission of electric power to the center. Electric power of approximately 120 million kW is provided by this variant of burning 500 million tons of coal annually. A total of 5-7 million kW of electric power can be technically transmitted over one high-voltage line. Therefore, approximately 20 of these lines would be required to transmit all the indicated power, which can hardly be regarded as realistic. At the same time, there are additional economic problems with this variant determined by the effect of an intensive electromagnetic field.

Moreover, the requirements on the methods of fuel use have changed considerably during the past few years. Specifically, burning of high-heat natural gas in some sectors of industry and especially in everyday life has become widespread. Therefore, it is natural to strive to see that the scale of gas utilization not decrease in the case of a decrease of natural gas production. Incidentally, it is this aspect of the matter that is emphasized in new developments on gasification in the United States with reference to the fact that tens of billions of dollars were invested in the pipeline gas transport network and that synthetic production of methane from coal will be required in the near future to completely load this network.

With regard to extensive power engineering, that is, to thermoelectric power plants, an increase of the fraction of gas or synthetic liquid fuel is also preferable for at least two reasons. One of them is that vapor-gas plants, which have higher efficiency than classical vapor-turbine plants and fuel economy 10-12 percent higher, may and should be used when burning these types of fuels. The second reason is related to the operating mode of electric power plants. Modern powerful coal and nuclear power plants easily operate under constant load and are poorly adapted for reducing their load during nighttime hours and on holidays when electric energy consumption by plants, municipal and other types of users is severely reduced. Hydroelectric plants can easily cope with operation under variable load but they are generally inadequate. In this regard a rather acute problem definitely exists. To solve it, it is extremely important to have gas or synthetic liquid fuel, upon use of which the output of the steam generator and energy block as a whole can be varied in practically any range of burning conditions, that is, almost from zero to 100 percent. Of course, mazut is just as convenient a fuel from this viewpoint, but further increase of it in power engineering cannot be counted on.

The next modern requirement on the use of fuel consists in the fact that the combustion products not pollute the atmosphere with sulphur dioxides. This requirement is becoming more and more rigid since discharge of sulphur dioxides into the atmosphere have already reached a rather high level with the existing scale of fuel consumption. And the most important task now is that these discharges be reduced if possible.

With regard to the enormous scale of fuel used and also with the restriction on petroleum and natural gas resources, the fuel and energy complex has recently attracted enormous attention to itself both in our country and abroad. This was naturally determined by the fact that fuel is the bread of industry and therefore progress in economics is impossible with a shortage of it. Among many papers of a general nature on this topic, the most complete and extensive is undoubtedly the article of president of the USSR Academy of Sciences Academician A. P. Aleksandrov.* It is quite rationally noted in it that, due to the natural restriction of fossil fuel reserves also required as raw material for the chemical industry, a course toward conservation of it should be maintained and that in this regard recovery of the heat of nuclear reactors should be utilized to the widest extent possible, including that for production of electric power, for heating cities and also for production purposes in industry. Thus, protection against environmental pollution will also be provided to a significant degree since no discharges having a harmful effect on the plant and animal world will occur during normal operation of nuclear reactors. The need for thermal refining of Siberian coal with water vapor to produce hydrocarbons in the form of gas or liquid fuel with high calorific value suitable for pipeline transport over long distances is also emphasized especially in the mentioned article. To achieve this last goal, we feel that the method of plasma gasification of coal is best.

One must dwell primarily on the efficiency of the process to evaluate plasma gasification. In the worst case when only water vapor, breakdown of which into oxygen

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*See: A. P. Aleksandrov, "Prospects of Power Engineering," IZVESTIYA, 10 April 1979.

and hydrogen occurs with expenditure of a relatively large amount of energy is used during gasification, plasmatrons consume an amount of electric power for production of which approximately 30 percent of the refined fuel is expended. In this case approximately $q_2' = 30 \cdot (1 - \eta_e) = 18$ percent of the thermal energy is lost at the power plant itself with efficiency of $\eta_e = 0.4$. Moreover, there are also losses of physical heat of the produced gas and other losses specific to a plasma gasifier which comprise a total of approximately 2 percent. Thus, in the worst case the energy efficiency of plasma gasification comprises approximately $\eta_g = 80$ percent.

In the other extreme case, gasification is accomplished on pure oxygen and without the use of plasmatrons. Electric power, for generation of which approximately 7 percent of the fuel used for refinement by gasification is consumed, is expended for oxygen production. With regard to the other mentioned heat losses comprising 2 percent, the efficiency of the process is approximately 91 percent in this case.

Actually, an oxygen and water vapor mixture is used in plasma gasification and at the same time plasmatrons operate. It is natural that the required concentration of water vapor and the output of plasmatrons should be selected experimentally from optimization of the process itself. Because of this, the efficiency of the process will be between the indicated values and a value of approximately 90 percent is quite achievable.

For comparative analysis of the efficiency of plasma gasification, let us recall that the efficiency of a classical gasifier comprises 40-50 percent. A diagram of it is shown in Figure 2.

In this case the fuel moves in the form of pieces from top to bottom and air entering from bottom to top is used to gasify it. It first passes through the slag layer and is heated somewhat. The heated air then enters the combustion zone and fuel gasification zone. The produced mixture of $CO+CO_2+N_2+O_2$ gases rises upwards and the last layers of the charge are heated due to its physical heat. The volatile (in the form of resinous) compounds contained in the solid fuel are distilled in this case and the fuel is dried, leading to ballasting of the produced gas by water vapor. Moreover, small fuel particles enter the gas in the form of priming. All these components reduce the quality of the gas and at the same time are unacceptable for conditions of transporting it through pipes to the user plants since they are capable of falling onto the walls and thus clogging the pipeline. To avoid this, the gas produced from these classical gasifiers is flushed with water in scrubbers. As a result the calorific value of the volatile fuel components is almost completely lost. At the same time there are relatively high heat losses related to slag and entrainment. In this regard, the total efficiency of this gasifier is at the mentioned rather low level. A significant feature of a classical gasifier is also the low calorific value of the produced gas, the component of which is only approximately 1,000-1,200 kcal/nm^3. This is determined mainly by the fact that the produced gas in gasifiers of this type is ballasted by atmospheric nitrogen used for the blast. A typical feature of a gasifier of this type is also its low productivity, which comprises only several tons per hour of refined solid fuel.

Nevertheless the role of gasifiers of this type in industry was enormous. They supplied numerous industrial furnaces with gas fuel for a long time. When these

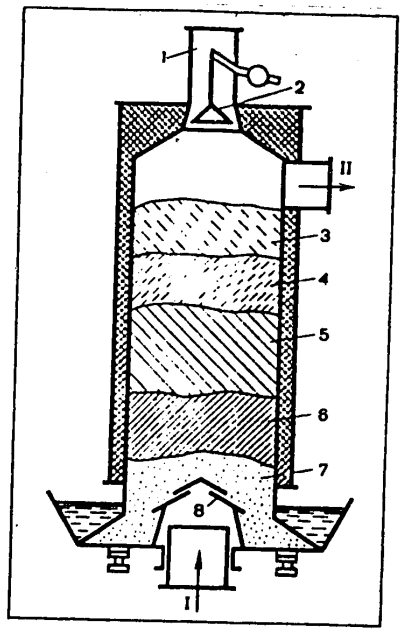

Figure 2. Diagram of Fixed-Bed Gasifier: 1--loading device; 2--gate; 3 and 4--drying and dry distillation zones; 5 and 6--combustion and recovery zones; 7--slag; 8--grate

gasifiers were used, the comparatively low calorific value of the produced gas is compensated to a known degree by preliminary heating to high temperature in a special air regenerator required for gas combustion. Industrial designs of the regenerator appeared at the end of the last century. Since then the gasifiers themselves have been developed and gasifiers with somewhat different schemes of the process and accordingly with different design forms were developed. Gasifiers operating under pressure with high efficiency and unit coal productivity up to 30 t/hr were developed and assimilated. With extensive development of natural gas, gas production from solid fuel using gasifiers decreased significantly and was retained among users who were unable to produce relatively inexpensive and at the same time high-calorific natural gas under local conditions.

Unlike classical gasifiers, air is not used at all in a plasma gasifier, but only a mixture of water vapor and oxygen is used, due to which the produced gas is not ballasted by nitrogen. At the same time the gas of a plasma gasifier is also essentially free of ballasting impurities of CO_2 and H_2O. This is achieved by the fact that the plasma gasification process proceeds at a temperature not below 1,100-1,200°C. According to conditions of thermodynamic equilibrium of the coal-gas system, the CO_2 and H_2O concentrations are close to zero at 900-1,000°C. This important result was achieved by Ye. I. Samuylov at the State Scientific Research Power Engineering Institute imeni G. M. Krzhizhanovskiy by the calculation-theoretical method. Of course, thermodynamic equilibrium is not achieved in a real process and therefore the ratios between the concentrations of the gas mixture components would be somewhat different at the mentioned temperatures. Because of this, a higher temperature, namely 1,100-1,200°C, must be maintained to eliminate the indicated ballasting impurities under real conditions, which was confirmed experimentally by G. N. Khudyakov on a laboratory plasmatron having output of 50 kW. Naturally, the appearance of resinous components typical for ordinary gasifiers is totally eliminated at this temperature level--they are converted to CO_2 and H_2.

Let us evaluate the technical and economic indicators of plasma gasification of Siberian coal with subsequent pipeline transport of methane or synthetic liquid fuel to the center of the Soviet Union with respect to refining 500 million tons of coal of the Kansk-Achinsk field annually. A little more than 200 billion nm^3 of methane annually can be produced upon refining of this coal. According to the existing plan, it is this quantity of natural gas that will be pumped annually through the Nadym-Torzhok gas pipelines. The four branches of the gas pipelines, each 1,420 mm in diameter, have a length of 2,460 km. The total cost of constructing the pipeline (together with the equipment of the gas pumpings stations) comprises 6.4 billion rubles according to plan.

The gasifier together with the dust preparation and ash trapping system is similar to a coal-dust steam generator but has a considerably smaller heating surface since the amount of cooled gases is approximately 1/5 that in a steam generator. Because of this, one can assume in the first approximation that the cost of a plasma gasifier is 30 percent of the cost of a coal dust station which consumes the same amount of coal. As already mentioned, the total output of coal dust stations consuming 500 million tons of Siberian coal annually comprises 120 million kW. Specific capital expenditures in construction of these electric power plants now comprise approximately 170 rubles/kW. Therefore, the total capital expenditures for development of plasma steam generators are estimated at $0.3\ 170 \cdot 120 \cdot 10^6 = 6.1$ billion rubles. According to calculations, approximately 270 of the most powerful oxygen machines, each with productivity of $70 \cdot 10^3$ nm^3/hr of oxygen and costing 8.4 million rubles, would be required for gasification in the considered case. Their total cost will comprise $8.4 \cdot 270 = 2.3$ billion rubles.

Moreover, development of electric power plants for local needs, which will consume approximately 15 percent of the fuel and whose output will comprise $0.15 \cdot 120 = 18$ million kW and the cost in capital expenditures of which will comprise $170 \cdot 18 \cdot 10^6 = 3.1$ billion rubles, is required to produce oxygen and to supply power to the plasmatrons.

Capital expenditures on scrubbing the gas of hydrogen sulfide, according to data of the State Scientific Research and Planning Institute of the Nitrogen Industry and Organic Synthesis Prducts (GIAP), comprise 8 rubles per 1,000 nm^3 of annual productivity. Therefore, to scrub 200 billion m^3 annually would require

$$80 \cdot \frac{200 \cdot 10^9}{10^3} = 1.6 \text{ billion rubles .}$$

Methane production from producer gas by means of catalysts, according to data of GIAP corresponding to foreign publications, requires capital expenditures at the rate of 40 rubles per 1,000 nm^3 annually, which comprises a total sum of

$$40 \cdot \frac{200 \cdot 10^9}{10^3} = 8 \text{ billion rubles.}$$

Thus, capital investments of 6.4 + 6.1 + 2.3 + 3.1 + 1.6 + 8 = 27.5 billion rubles are required to refine 500 million tons of Siberian coal annually, to produce synthetic natural gas (methane) from it and to transport it to the center of the USSR.

As is known, the concept of comparison fuel, having calorific value of 7,000 kcal/kg is used extensively in power engineering. The Siberian coal of the Kansk-Achinsk field has calorific value of 3,740 kcal/kg. As a result, 500 million tons of this coal corresponds to

$$\frac{3{,}740 \cdot 500}{7{,}000} = 270 \text{ million tons of comparison fuel.}$$

Thus, the specific capital expenditures for comparison fuel will comprise

$$\frac{27.5 \cdot 10^9}{270 \cdot 10^3} = 100 \text{ rubles/ton of comparison fuel.}$$

Similar expenditures for oil and gas production reach 116 rubles/ton of comparison fuel; therefore, the given value of 100 rubles/ton of comparison fuel should be regarded as acceptable.

Let us also estimate the increase in the cost of fuel related to the indicated capital investments. According to available data,* expenditures for renovation and major overhaul comprise 8 percent of the cost of equipment at coal dust stations and expenditures for routine maintenance and operation comprise another 6-7 percent. Therefore, the total operating expenses for plasma gasification and transport of gas can be estimated at a maximum of 15 percent. Consequently, the increase in the cost of the fuel comprises 0.15·100 = 15 rubles/ton of comparison fuel. Since Siberian fuel is itself relatively inexpensive (4.8 rubles for transport up to 1,000 km), the total cost of methane at the center will be no more than 20 rubles/ton of comparison fuel. For comparison let us add that fuel with average cost of 16 rubles/ton of comparison fuel is now used in the Mosenergo [Moscow Regional Administration of Power System Management] system.

When coal is refined to liquid hydrocarbon fuel and namely to methanol CH_3OH, capital expenditures on preliminary gasification and scrubbing of gas of hydrogen sulfide remain the same as in methane production and comprise 6.1 + 2.3 + 3.1 + + 1.6 = 12.1 billion rubles. Capital expenditures on methanol production from gasifier gas using catalysts, according to data of GIAP, comprise 90 rubles per ton of methanol annually. Approximately 350 million tons of methanol with calorific value of 5,340 kcal/kg can be produced from 500 million tons of Siberian coal. Therefore, capital investments in production of it comprise $90 \cdot 350 \cdot 10^6 = 31.5$ billion rubles.

Methanol has a density of approximately 800 kg/m^3. At the accepted pumping rate of 3.5 m/s, 350 million tons of methanol can be transported over three branches of a pipeline 1,420 meters in diameter. Capital expenditures on these pipelines with all pumping station equipment will comprise approximately

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* See: A. Ya. Avrukh, "Problemy sebestoimosti elektricheskoy i teplovoy energii" [Problems of the Cost of Electric and Thermal Energy], Moscow, Energiya, 1966.

$$\frac{6.4}{4} \cdot 3 = 4.8 \text{ billion rubles.}$$

The total capital investments in refining 500 million tons of Siberian coal annually to methanol and with pipeline transport of the methanol to the center of the USSR will comprise 12.1 + 31.5 + 4.8 = 48.4 billion rubles.

Thus, the expenditures required to refine Siberian coal to liquid fuel--methanol--are considerably higher, almost twofold higher, than in refining to a high-calorific gas--methane. Nevertheless, this refining is feasible since methanol, like any other liquid hydrocarbon fuel, is an alternative to gasoline and will be required in the future, specifically, for internal combustion engines.

Both methane and liquid synthetic fuel are undoubtedly more voluble qualitatively than the initial coal. They can be used in steam generator plants where an efficiency of 45 percent is achieved (compared to 41 percent at modern steam power GRES). In this regard, fuel economy of 10-12 percent is achieved, which essentially completely compensates for the heat losses related to the process of plasma gasification of coal. The especially high conservation from use of these types of fuel is determined, as is known, by the fact that optimum operating conditions of thermoelectric power plants during the peak part of the load schedule of the energy system are provided, including peak electric power plants with gas turbines.

It will apparently be economically feasible to use plasma gasification of coal with respect to powerful gas-fired boiler units. Sufficiently reliable numerical data can be obtained in this regard only on the basis of a real design. Nevertheless, the available estimates are favorable.

A plasma gasifier with two operating oxygen plants with productivity of 70,000 nm^3 of oxygen each per hour, which consume energy of approximately 50 MW, and with plasmatrons having total output of approximately 100 MW will be required for a gas fired boiler unit having capacity of 1,000 MW, being developed at TsKTI [Central Scientific Research, Planning and Design Boiler and Turbine Institute imeni I. I. Palzulov]. In this case the dust preparation and ash trapping equipment will be the same as in a coal-pulverizing GRES and only the plasma gasifier itself having the form of a furnace chamber will be specific. Its cost cannot be relatively high and should be approximately compensated for by a saving of capital expenditures on the compact high-pressure steam generator of the gas-fired boiler.

The capital expenditures on the oxygen plant consisting of three machines with total cost of 25.2 million rubles and also of the sulphur scrubbing plant, which will cost 14.5 million rubles (according to data of GIAP) with output of 1 million kW, are also specific. Thus, these total expenditures will comprise 25.2 + 14.5 = 39.7 million rubles.

Scrubbing the flue gases of a coal boiler plant of SO_2 is approximate in cost, as is known, to the cost of the boiler plant itself, which comprises approximately 50 percent of the total capital expenditures of a coal-fired GRES. Therefore, using specific capital expenditures on a GRES of 170 rubles per standard kilowatt (without sulphur scrubbing), we find capital expenditures for a coal-pulverizing boiler plant of 85 million rubles. Consequently, one can assume approximately that the capital expenditures for scrubbing the flue gases of SO_2 in a coal-fired boiler with output of 1 million kW will be approximately 85 million rubles.

Comparing the given figures, one can assume that development of a gas-fired boiler rated at 1 million kW may provide a saving of several tens of million rubles (compared to a coal-pulverizing boiler with the same capacity having sulphur scrubbing). However, it may be that the main thing is that scrubbing the gases of hydrogen sulfide has been totally developed and it is operationally simpler than scrubbing flue gases of SO_2.

The mentioned efficiency of approximately 90 percent during plasma gasification determines the yield of the potential thermal energy with respect to the potential thermal energy in the initial fuel. But it can be increased if plasmatrons are supplied with electric power from an AES rather than from a thermoelectric power plant. In this case the problem of conservation of fossil fuel by using nuclear fuel, the timeliness of which was noted very clearly by Academician A. P. Aleksandrov in the mentioned article, will also be resolved to a known degree. By breaking down water vapor into oxygen and hydrogen and by enriching the produced gas with hydrogen, this indicator can be raised significantly higher than unity. On this basis one can also produce pure hydrogen and the efficiency of this process, which proceeds at high temperature and in the presence of carbon, at least according to thermodynamic calculations, is relatively very high. Without going into details, let us note that according to calculations, production of hydrogen using plasma gasification of coal is three times more efficient than the electrolysis method and is approximately 20 times more efficient than the cost of hydrogen.

The idea of using nuclear power in production processes, including processes for fuel refinement, has been discussed widely. But in this case one usually has in mind the use of thermal energy produced from gas-cooled (helium) nuclear reactors with gas temperature of 800-900°C. Development of this type of high-temperature reactors is a complex task. We are talking here about use of electric power produced at AES. In this case, of course the energy efficiency of the process is essentially lower than when using thermal energy from a high-temperature reactor. Nevertheless, the use of electric power from AES will generally be rational in the future.

It is significant that efficient operation of a powerful gasifier according to the diagram shown in Figure 1, with purely oxygen air supply but without plasmatrons, is impossible. In this case the considerable nonuniformity of the temperature field which determines the moderation of the gasification process and also deterioration of the quality of the gas due to the appearance of appreciable concentrations of ballasting impurities of CO_2 and H_2O in it are inevitable.

To avoid this, either a solid-bed gasifier similar to that shown in Figure 2 or a so-called fluidized-bed gasifier* in which sufficient homogeneity of temperature conditions in the coal gasification zone is provided is used with purely oxygen air supply, but other problems which considerably restrict its unit output appear. One of them is that the air blast in this gasifier is limited by entrainment from the layer of fine fuel particles by the flow of generated gas moving through the bed from bottom to top.

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* See: R. G. Schwieger, "Burning Tomorrow's Fuels," POWER, Vol 123, No 2, 1979.

The technical problems of more or less uniform distribution of the incoming fuel through the bed and also removal of slag and ash from it are also very complex. These problems are known to a specific degree by the experience of operating boiler furnaces with block combustion of fuel in the bed. Their fuel capacity is limited to a maximum of approximately 15 tons/hr. Unlike them, up to 500 tons of coal per hour, as already mentioned, is burned in modern coal-pulverizing furnaces of steam boilers. One can count on approximately the same jump upon conversion to plasma gasification of coal dust. In this case a high temperature level in the gas jet directly in the body of the plasma reactor is provided when using plasmatrons, due to which the coal dust gasification process is mainly completed in the reactor itself. Therefore, the output of the gasifier is determined by the output of the plasma reactor 2 and by the number of reactors installed on the walls of the chamber 1 (see Figure 1).

With regard to the conditions of actual realization of plasma gasification of coal on an industrial scale, they are quite realistic from a technical aspect. The installations with expansion turbine developed by Academician P. L. Kapitsa to produce oxygen from air are now being serially produced in our country with specific expenditure of electric power of approximately 0.4 kW/hr per 1 nm^3 of oxygen. Four of these installations, which is of course quite acceptable technically, are required for a gasifier designed to refine 1,000 tons/hr of Kansk-Achinsk coal. As is known, production and operation of oxygen installations of this type have been developed and they operate quite reliably with planned shutdown for preventive maintenance every one or two years.

Plasmatrons have until now been mainly produced in individual units. Nevertheless, great success has been achieved in development of them. They are used mainly as apparatus for heating to very high temperature one or another type of gas then used for production purposes. Specifically, the plasma produced in this manner is used for testing articles in a gas flow of very high temperature, for melting refractory materials and application of them in a then layer to articles and also for other periodic processes. Plasmatrons also find application in continuous processes of chemical and metallurgical technology. In this regard, the operating life of plastmatrons, that is, the length of their continuous operation, also acquires especially important significance. It is necessary that the operating life of powerful plasmatrons comprise hundreds of hours with respect to plasma gasifiers. There are specific difficulties, as specialists well know, on the path toward this goal. Of course, many problems of a technical nature, related to provision of reliability and economy of operation, must be resolved when developing a very high-output plasma gasifier. Work on solution of them is timely, very important and at the same time attractive since we are really talking about a new technology.

6521
CSO: 1841/57

STATUS AND PROSPECTS FOR DEVELOPING USSR'S UNDERGROUND COAL GASIFICATION

Moscow KHIMIYA TVERDOGO TOPLIVA in Russian No 6, Nov-Dec 80 pp 57-60

[Article by K. N. Zvyagintsev, M. A. Kulakova and A. F. Volk]

[Text] The methods and prospects of underground coal gasification in the USSR by blowing air and a steam-oxygen mixture through a seam are described.

Experimentation with and scientific research on underground coal gasification were started in 1933 in lignite and coal deposits existing under different mining and geological conditions. At this stage, identifying the processes associated with underground coal gasification with those occurring in conventional gas generators, researchers made it their objective to create and perpetuate a "working" layer of fuel in an underground gas generator. This approach was unsuccessful.

The second state in experimentation with underground coal gasification, which began in 1935, was based on the principle of gasifying coal and unworked deposits without their artificial fractionation.

The procedure of underground coal gasification developed in the USSR is based on shaftless preparation of underground gas generators, and gasification in channels within which the coal interacts with air, steam, and gas blown through.

Shaftless preparation involves drilling vertical, slant, and slant-horizontal boreholes into the coal seam from the surface of the ground, and creating gasification channels passing between the boreholes through the coal seam.

The following methods are used to create reaction channels in the coal seam: filtrational crosscutting or burning out of channels, which capitalizes on the gas permeability of the coal seam, hydraulic disintegration of the coal seam with water, and slant-horizontal drilling.

Reaction zones form in the gasification channels, and gasification begins, proceeding as a semi-inverted process. Chemical reactions proceeding in the reaction channels are similar to those in a gas generator.

Combustible gas is obtained in channels of varying length (depending on the form of the coal seam) by injecting air and steam into some holes and withdrawing gas from others.

As gas is removed from the coal seam, in response to rock pressure the overlying material shifts to fill in the spaces from which gas had been removed. Owing to this the dimensions and structure of the gasification channels remain more or less constant for a long period of time, resulting in relative constancy of the composition of the obtained gas. Timely preparations involving drilling and crosscutting of new holes insures a generally regular gas discharge.

The appropriate drying methods have been developed for flooded coal seams undergoing gasification. These methods are also based on the shaftless principle, and they generally entail pumping the underground water out of the corresponding horizons through drain holes.

Practical underground coal gasification projects were conducted with coal seams varying in class (lignite and coal) situated in different mining and geological conditions. Six experimental industrial and industrial underground coal gasification stations operated in different periods of time. These enterprises were created mainly to solve technical problems (with the exception of the "Podzemgaz" station in Angren), and their productive capacities were low.

Today there are two underground gasification stations operating in the Soviet Union: The Angren station in Central Asia, and the Yuzhno-Abinskaya station in the Kuznetsk Basin.

During the time of their operation, they produced 21 million m^3 of producer gas with heat of combustion equal to 950-1,110 kcal/m^3 (as opposed to the 750-800 kcal/m^3 achieved with the older system). The degree of utilization of industrial coal reserves was 100 percent, and the chemical efficiency of gasification was 70 percent, which exceeds the average achieved with the "Podzemgaz" station in Angren.

The Yuzhno-Abinskaya station has been operating since 1955. Steeply sloping coal seams 150-320 meters deep are gasified. The seams are 3-10 meters thick. They slope at a 55-57° angle. The coal seam is flooded. The underground water is drained off during gasification.

Gasification of the coal seam entails injecting air into the initial gasification channel, created by filtrational crosscutting with air under high pressure and hydraulic disintegration of the coal seam through straight holes, and withdrawal of gas through slant gas wells drilled along the axis of the coal seam. The gas wells are cased to a depth of 80-100 meters, and the distance between straight holes is 15-20 meters.

Work was done at the Yuzhno-Abinskaya station to develop deep horizons (down to 320 meters). This involved shaftless preparation of the coal for gasification and shaftless drying of the coal formations to insure high chemical efficiency of gasification and complete removal of gas from the industrial coal reserves.

To support the transition to operation of gas generators at the Yuzhno-Abinskaya station from 130-150 to 200-320 meters, a new method was developed for starting up gas wells, entailing creation of counterpressure within them, which reduces the influx of underground water into the area of channel burning.

Today, underground coal gasification is used as a means for acquiring gas to be employed predominantly in power production. In terms of the future, however, it should be considered that underground gas generators may become a major source of gases to be used in the production of synthetic chemicals (alcohols, ammonia, liquid fuel, and so on).

The positive experience of obtaining industrial gas from Moscow lignite in natural conditions using experimental set-ups demonstrated the real possibilities for this process.

Industrial gas suited for synthesis of chemical products was obtained with an enriched oxygen blast mixture (65 percent O_2) to which steam was added at a ratio of 300-400 gm/m^3 blast mixture. The approximate composition of this industrial gas was as follows, percent: H_2S--2.9; CO_2--28.4; C_mH_n--0.2; CO--15.6; H_2--35; CH_4--1.8; N_2--15.7; $Q = 1,750$ $kcal/m^3$. The minimum heat of combustion of the gas following removal of hydrogen sulfide and carbon dioxide is 2,300 $kcal/m^3$. Gasification proceeded stably in time.

The energy crisis and the revealed shortage of natural gas and petroleum have made it extremely important to utilize the enormous resources of solid fuel, which exceed the petroleum and gas reserves by dozens of times. In this connection a number of capitalist countries (USA, Belgium, FRG, Canada, and so on) have resumed major scientific research and experimentation in coal gasification and underground coal gasification with the purpose of obtaining a natural gas substitute and a hydrogen-containing raw material.

The work that has been done in the Soviet Union has raised considerable interest among a number of developed capitalist countries seeking licenses. Thus Texas Utilities Services, Inc., USA, obtained a license from the USSR in 1975 for the underground coal gasification process, and it is now using Soviet technology to develop underground gasification of lignite deposits in the state of Texas.

Much attention is also being devoted to underground coal gasification in developed capitalist countries such as the FRG, Belgium, and Japan, which have developed extensive programs for production of low- and high-calorie gases, including one at great depth under high pressure (40-60 kg/cm^2) using a steam-oxygen blast mixture.

Considering the presence of significant coal reserves, the limited reserves of coal permitting open-pit mining, and the well known difficulties associated with deep-shaft coal mining, our country could benefit from scientific research and industrial experimentation on deep horizons with the objective of underground gasification; there also may be advantages to high-pressure blowing as well as to utilization of coal deposits having a high concentration of sulfur and of high-ash and high-moisture coal. Oxygen-enriched air would best be used as the blowing agent. The experience of conventional mining operations has shown that at depths greater than 700-800 meters, rock lining a coal seam acquires plastic properties. Therefore it can become an impermeable barrier preventing the passage of gases, and owing to its deformation it may promote fast sealing of cracks formed during exploitation, which should reduce gas leakage from the underground gas generator.

The transition to greater depth should produce a number of technical advantages, to include injecting blowing agent at higher pressure during gasification, and reducing losses (leakage) of gas.

When high pressure (10-30 atmospheres) is used in underground coal gasification, the heat of combustion of the gas rises due to change in the chemical equilibrium in the direction of methane formation. Producer gas obtained under pressure may be utilized more effectively by electric power plants employing a combined cycle: gas turbine--steam turbine. From the economical point of view the use of high pressure makes it possible to reduce well diameter and significantly decrease the amount of electric power consumed to transport the gas.

Gasification entailing the use of oxygen and oxygen-enriched air to which appropriate amounts of steam or carbon dioxide are added would make it possible to obtain industrial gas of any composition whatsoever, suitable for synthesis of many chemical products, and reducing gases for ferrous and nonferrous metallurgy.

Industrial gas production affords a possibility for simple methods of H_2S and CO_2 removal, and acquisition of gas with a high heat of combustion--up to 4,000 kcal/m^3--that can be transported for a distance of 200-250 km without the use of compressors.

Thus deep underground coal gasification entailing the use of high-pressure oxygen-air blowing agent may produce natural gas substitutes for synthetic chemical industry. However, new high-pressure gasification procedures will have to be developed for deep gasification, and the number of wells employed will have to be decreased with the goal of reducing their influence upon the cost of the gas.

Use of coal having a high sulfur and moisture content in underground coal gasification also seems to be promising. High-sulfur coal cannot be used in gasification processes on the ground in connection with formation of SO_2 during combustion, which pollutes the environment; moreover it is impossible to clean the coal beforehand without subjecting it to thermal processing. In underground gasification of high-sulfur coal, bound sulfur contained in the coal transforms into hydrogen sulfide, which can easily be removed from the gas.

Evaluating the advantages of underground coal gasification, we should note the following features accompanying this process: Heavy work harmful to human health is eliminated underground and in transportation of the fuel; additional preparation of the fuel by the consumer is not required; the condition of the air basin improves. The fertile soil layer is not disturbed, and the need for dumping waste rock over large areas is eliminated.

Conclusions

1. The procedures for underground coal gasification at depths down to 320 meters have been developed in the Soviet Union.

When air is used as the blast agent, the heat of combustion of gas produced by underground gasification of lignite is 700-800 kcal/m^3, and that of coal is

800-1,050 kcal/m^3. The heat of combustion of gas produced by underground gasification rises to 1,800 kcal/m^3 with the use of a steam-oxygen blast mixture at conventional pressure.

2. The procedures developed in the Soviet Union are a dependable foundation for underground gasification of deeply lying coal with a steam-oxygen blast mixture at a pressure of 20-30 atmospheres.

11004
CSO: 8144/0424-A

ORGANOPHOSPHORUS COMPOUNDS

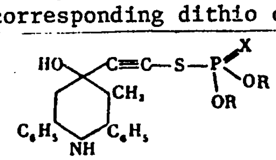
UDC 577.1

NEW SELECTIVE ACARICIDES IN SERIES OF THIOETHYNYL ETHERS OF THIOPHOSPHORIC AND DITHIOPHOSPHORIC ACIDS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 259, No 2, 1981 (manuscript received 28 Oct 80) pp 474-477

[Article by T. I. Vasil'yeva, K. N. Savchenko, Ye. K. Balashova, V. I. Rosengart, O. Ye. Sherstobitov, A. P. Brestkin, L. A. Vikhreva, N. N. Godovikov, N. B. Abdullayev, B. D. Abiyurov and Academician M. I. Kabachnik, Institute of Organoelemental Compounds imeni Nesmeyanov, USSR Academy of Sciences, Moscow]

[Text] The creation of new, selectively-acting insect acaricides is an important task in the search for compounds meeting modern demands. Of great value are compounds which not only have a low toxicity for warm-blooded animals but also show a selective activity with respect to various species of Arthropoda. We have found just such effects in studying the insect acaricidal activity of 2,6-diphenyl-3-methyl-4-(dialkoxyphosphorylmercaptoethynyl)piperidine-4-oles (I) and their corresponding dithio derivatives (II):



$R = CH_3, C_2H_5, C_3H_7, C_4H_9$; $x = O$ (I) $x = S$ (II)

In each group of compounds were also studied stable epimers with an equitorial (E) and axial (A) arrangement of the substituted ethynyl group.

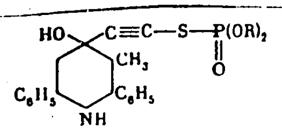
The synthesis of the compounds studied has been described previously (1, 2). For the substances named, the antiesterase activity was studied relative to acetylcholine esterase of human erythrocytes (AChE), butyrylcholine esterase of horse blood serum (BChE), choline esterase (ChE), and carboxyl esterase (KBE) of the spider mite, as well as the insecticidal and acaricidal activity for several species of Arthropoda.

Change in the choline esterase activity was determined by the Ellman method (3) using acetylthiocholine or propionylthiocholine (for mites) as the substrate, in a concentration of $1 \cdot 10^{-3}$ M at 25° C. In determining the activity of carboxyl esterase, the substrate was paranitrophenylthioacetate ($1 \cdot 10^{-3}$M). The antiesterase activity of the compounds was expressed in the form of a bimolecular constant of anzyme inhibition rate (k_{II}).

Contact insecticidal activity was determined on the cereal aphid (Schizaphis graminum Rond), rice weevil (Sitophilus oryzae L.) and mealy bug (Pseudococcus martinus L.). Contact acaricidal action was studied on the ordinary spider mite (Tetranychus urticae Koch) and acariphage phytosyulus (Phytosyulus persimiles Ah). The substances investigated were used in the form of an emulsion. The Arthropoda were sprayed in Petri dishes in the amount of 0.005 ml of working fluid per 1 cm^2. In determining the acaricidal activity, kidney beans populated by the mite the day before were carefully sprayed. The experiment was repeated three times, with 30-50 experimental specimens each time.

The toxic effect was determined for the cereal aphid after 24 hours; the spider mite and phytosyulus, after 48 hours; the mealy bug and rice weevil, 1.3 and 5 days after treatment. The criterion for estimating the compounds' toxicity was the amount of CK_{50}, whose calculation was done using the method of least squares for probit analysis of the curves of Rethality (4).

Table 1. Antiesterase Activity of Compounds of the Structure:



($k_{II} M^{-1}$ мин$^{-1}$) (1)

R	Эпимер (2)	АХЭ (3)	БуХЭ (4)	ХЭ (5)	КБЭ (6)
CH_3	А	$1 \cdot 10^2$	$7{,}8 \cdot 10^2$	$1 \cdot 10^2$	$5{,}5 \cdot 10^2$
CH_3	Э	$1 \cdot 10^2$	$1{,}7 \cdot 10^3$	$1 \cdot 10^2$	$1{,}0 \cdot 10^2$
C_2H_5	А	$1{,}5 \cdot 10^2$	$3{,}6 \cdot 10^3$	$3{,}2 \cdot 10^2$	$4{,}0 \cdot 10^2$
C_2H_5	Э	$5{,}4 \cdot 10^3$	$4{,}2 \cdot 10^4$	$1{,}0 \cdot 10^4$	$2{,}9 \cdot 10^3$
C_3H_7	А	$1{,}9 \cdot 10^2$	$4{,}6 \cdot 10^4$	—	$1{,}5 \cdot 10^3$
C_3H_7	Э	$0{,}7 \cdot 10^3$	$1{,}1 \cdot 10^4$	$1{,}8 \cdot 10^2$	$2{,}4 \cdot 10^3$
C_4H_9*	А	$1{,}0 \cdot 10^3$	$4{,}5 \cdot 10^{-5}$	$1 \cdot 10^2$	$5{,}0 \cdot 10^{-4}$
C_4H_9*	Э	$3{,}9 \cdot 10^2$	$6{,}0 \cdot 10^{-6}$	$1 \cdot 10^2$	$6{,}6 \cdot 10^{-5}$

(7) * Эти соединения по отношению к БуХЭ и карбоксилэстеразе обладают обратимым типом торможения, поэтому их активность выражена в виде I_{50}, т.е. концентрации, при которой наблюдается 50% торможения.

Key:
1. ($k_{II} M^{-1}$ min^{-1})
2. Epimer
3. AChE
4. BChE
5. ChE
6. KBE
7. These compounds have a reversible type of inhibition relative to BChE and carboxyl esterase; therefore, their activity is expressed in the form of I_{50}, i.e., the concentration at which 50% inhibition is observed.

The toxicity for mammals was determined on white mice by the Kerber method with subcutaneous injection of the compounds in a 50% solution of dimethylsulfoxide in a volume of 0.05-0.1 ml per 10 g, and expressed in mg/kg.

The results of determining the antiesterase action of the monothio derivatives are presented in Table 1. It can be seen from this table that all the substances are distinguished by their low ability to depress choline esterase, of varying origin, and mite carboxyl esterase. Clear differences are not distinguished between the epimers. All the substances are inhibitors of an irreversible type of action, with the exception of dibutoxy derivatives, which are reversible inhibitors for BChE and KBE.

The monothio and dithio derivatives studied exhibited low entomotoxicity.

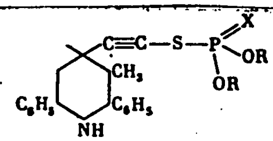
For example, in the 0.1% concentration for the cereal aphid, all the substances investigated induced death in the range of 15-25%; for the rice weevil and mealy bug, 1-2%.

Table 2 presents the results of determining the toxicity of the compounds for mites and mice.

The toxicity for mice is clearly expressed, and, according to the classification used (5), the substances investigated can be considered medium-toxic. The E epimer is 1.5-2 times less toxic than epimer A. The clinical picture of the toxic effect does not have the indications of cholinergic stimulation (salivation, exophthalmia, intensified intestinal peristalsis, and others) so characteristic of poisoning by anticholine esterase substances. The absence of inhibition of AChE of the brain, during action of the substances in lethal doses, also in an indication against an anticholinesterase mechanism of death in the mice. It should be noted that the dithio derivatives are practically undistinguished in toxicity from the monothio derivatives, which also is completely uncharacteristic for compounds with anticholinesterase action.

All the substances tested exhibit acaricidal properties to one degree or another, despite their low anticholinesterase activity. The most pronounced effect with respect to the ordinary spider mite is possessed by diethoxy- and dipropoxy derivatives of the monothiophosphates, which are almost as toxic as the standard Rogor. Differences between the epimers were not noted with these compounds.

Table 2. Toxicity for Mice and Mites of Compounds of the Type:



R	(1) Эпимер	x	(2) Мыши ЛД$_{50}$, мг/кг	(3) Паутинный клещ		(4) Фитосейулюс		(5) Показатель селективности	
				СК$_{50}$	СК$_{95}$	СК$_{50}$	СК$_{95}$	СК$_{50}$	СК$_{95}$
CH_3^*	А	S	180						
CH_3^*	Э	S	250						
C_2H_5	А	S	190	0,005	0,012	0,065	0,120	13	10
C_2H_5	Э	S	510	0,010	0,023	0,190	0,680	19	30
C_3H_7	А	S	270	0,018	0,037	0,130	0,290	7,2	8
C_3H_7	Э	S	390	0,027	0,048	0,120	0,270	4,4	5,6
CH_3^*	А	O	230						
CH_3^*	Э	O	420						
C_2H_5	А	O	160	0,005	0,009	0,260	0,650	52	72
C_2H_5	Э	O	330	0,006	0,010	0,200	0,490	33	50
C_3H_7	А	O	220	0,007	0,013	0,200	0,360	30	28
C_3H_7	Э	O	390	0,006	0,012	0,210	0,410	35	34
C_4H_9	А	O	215	0,05	0,11	0,230	0,710	4,6	6,4
C_4H_9	Э	O	330	0,052	0,118				
(6) Рогор (7) (эталон)				0,002–0,005	0,006–0,0009	0,00005 (при окунании) (8)			

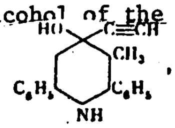
(9) * Соединения оказались малотоксичными, при концентрации 0,05% смертность была от 10 до 20%.

Key:

1. Epimer
2. Mice, LD_{50}, mg/kg
3. Spider mite
4. Phytosyulus
5. Selectivity index
6. Rogor
7. (Standard)
8. (with immersion)
9. The compounds are low-toxic; at a concentration of 0.05%, the death rate was 10 to 20%.

For the compounds studied, a minor toxicity was established for the predatory mites phytosyulus, which is widely used in agriculture to combat the spider mite under closed soil conditions. These substances are substantially more toxic for the spider mite than for the acariphage. The selectivity index (ratio of CK_{50} or CK_{95} of the entomophage to CK_{50} or CK_{95} of the phytophage) for the more active compounds reaches 35-52 at CK_{50} and 34-72 at CK_{95}. The highest selectivity (52-72) belongs to the epimer (E) of the diethoxymonothio derivative.

At the present time, it is difficult to answer the question of the possible mechanism of action of the compounds studied, and to what their acaricidal activity and selectivity of action are due. It can only be noted that the initial nonphosphorylated alcohol of the structure



does not have an acaricidal activity, as our experiments have shown.

In evaluating the acaricidal action mechanism of the substances studied, attention should be directed to the fact that this action is not at all correlated with their ability to inhibit choline esterase of the spider mite. A comparison of the data in Tables 1 and 2 shows that even high-acaricidal compounds, as a rule, have an extremely low anticholinesterase activity, while the only substance with a relatively high activity (k_{II} - 1 10^4 M^{-1} min^{-1}) shows no difference whatsoever from compounds close to it, whose anticholinesterase activity is lower by a factor of two.

The question of the reasons for such a selectivity is of great theoretical interest. Answering this question requires fundamental research, directed on the one hand towards studying the physiological peculiarities of Arthropoda, in particular, elucidating the mechanism of death of Arthropoda given poisoning by organophosphorous compounds of this type; and on the other hand, towards the ability of this type of substance to affect other vital systems besides choline esterase. The solution of these theoretical questions can have far-reaching practical consequences, involving creation of new, highly effective insectoacaricides.

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9875
CSO: 1841/149

PETROLEUM PROCESSING TECHNOLOGY

UDC 553.98.004

DEVELOPMENT OF SIBERIAN HYDROCARBON RESOURCES

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 5, May 81 pp 55-61

[Article by I. V. Kalechits, head of the chemistry section, State Committee for Science and Technology, doctor of chemical sciences: "Problems of the Chemical and Energy Utilization of Siberia's Hydrocarbon Resources"]

[Text] With its immense raw material and energy resources, Siberia has long been a base for the accelerated development of power intensive chemical industrial processes. Long-range national economic plans provide for rapid development rates of the chemical industry in the eastern regions of the country compared with the European part, especially its power intensive subsectors. A series of large-scale scientific and technical problems must be solved if these plans are to achieve fruition.

The USSR State Committee for Science and Technology, USSR Gosplan and USSR Academy of Sciences have jointly developed a series of specific integrated programs and programs for solving the most important scientific and technical problems, which will be implemented during the 11th and 12th Five-Year Plans. As is known, the difference between the two types of programs is that in the specific integrated ones, besides scientific and experimental design work, measures are stipulated for the application of new developments to the extent required for complete satisfaction of the economy's needs, i.e., the corresponding tasks will become part of the national economic plan. The latter type of programs also become an integral part of the plan for the social and economic development of the USSR, but terminate upon establishment of the initial production or the first industrial series.

Almost all programs in the chemical field contain tasks for the development of Siberia's natural resources and constructing large-scale chemical enterprises there, including several which are unique in our country or are the first of their kind in the world.

Foremost among the most important tasks of such programs, and the scientific problems which must be solved to realize them, are questions of optimal chemical and energy utilization of Siberia's hydrocarbon resources. Siberia has already become a main supplier of this resource, and its role in producing oil, gas and their substitutes will continue to grow in coming decades.

In the last seven or eight years, the efficient use of hydrocarbon resources has become a major world problems, which basically revolves around the growing disproportion between the structure of consumption of various types of organic resources (primarily for producing energy) and the correlation of their natural reserves. According to UN data, world organic fuel consumption is presently running at 8.8 billion tons of conventional fuel per year, of which oil, gas condensate and natural gas account for 67%, and bituminous and brown coal account for 33%. The proportion of oil and gas consumed is even higher in the industrially developed nations. In the United States, for example, they provide 74.1% of its energy, while coal accounts for 18.5% (hydroelectric stations account for 3.5%, and atomic power plants for 3.9%)[1]. Besides power generation, this resource's use is also increasing in the chemical industry. Some 95% of organic synthesis products currently are made from oil and gas[2], and since the scale of this production is growing rapidly, the chemical use of oil and gas is being compared with that of energy. According to predictions[3], by the year 2000 the chemical industry (excluding the socialist countries) will use 17% of all oil consumed, and 50% by the year 2020.

However, according to the most objective estimates, provided in 1978 at the 10th World Energy Conference, the structure of world-wide geological resources and proven recoverable reserves of organic stocks is diametrically opposite that of fossil organic fuel consumption: bituminous and brown coal account for 93% of all geological resources and 74% of all proven recoverable resources, while oil and gas account for only 7 and 26%, respectively[4].

It is obviously impossible to maintain such a disproportion for long, or intensively increase oil and gas output. The near future will see a stabilization, then reduction in their production. These factors have led to the enormous interest throughout the world in energy conservation and the additional use of coal and other alternative energy sources in the fuel energy balance.

Although the Soviet Union has substantial reserves of oil and gas, primarily due to its Siberian desposits, we also have an obligation to provide for the country's future by developing measures to supplement these resources and use them efficiently.

The set of specific integrated programs and the programs for solving the most important scientific and technical problems, developed by the State Committee for Science and Technology, Gosplan and USSR Academy of Sciences for 1981-1985, is directly or indirectly devoted to these issues.

A prime example of this is the specific integrated program to develop processes and equipment for producing synthetic liquid and gas hydrocarbons from oil and other non-petroleum resources. Such a program, developed for the first time in the country's history, is to create the scientific and technical base for a new branch of the economy: synthetic fuel production. Under this program, in the 1980's various technological solutions in this field will be tested at large-scale industrial pilot plants; the technical and economic basis for building the first industrial enterprise will be developed, and its construction will be initiated in the 12th Five-Year Plan. Once these problems are solved, the country will be in a position to set up a series of enterprises whose output will supplement our liquid and gas fuel resources, and the chemical industry's raw material base, through hydrogenation and gasification of coal. The program primarily involves the processing of inexpensive Kansk-Achinsk coal, so the work will basically take place in Siberia.

The program provides for the construction of large-scale industrial pilot plants for:

- high-speed coal pyrolysis, with corresponding units for processing the pyrolysis products: semicoke and tar. This plant will make it possible to obtain data to develop methods of combining pyrolysis with energy production, and using the products obtained as chemical raw material;

- liquefaction of coal by the hydrogenation method. The plant's operation will lead to selection of the optimal version for obtaining synthetic oil or synthetic gasoline on an industrial scale; and

- gasification of coal, followed by acquisition of methanol or hydrocarbons from the gas synthesis. There are various possibilities here, including that of combining hydrocarbon synthesis with MHD electric power generation, being developed by Krasnoyarsk scientists. The process of obtaining liquid fuels from methanol can be very promising; catalysts for this are currently being developed in the Catalysis Institute of the Siberian Branch of the USSR Academy of Sciences.

This program will be of great national importance, since its implementation will make it possible to guarantee the USSR's fuel energy balance against any contingencies. The program also determines the most economic method of transmitting cheap Siberian power to the European part of the country. This might be synthetic oil and pipeline transport, or refined coal, or electric power transmitted by superconducting transmission lines.

The goal of this program is thus to replenish future hydrocarbon resources. At the same time, their intensive conservation is no less important, and even more pressing. We are presently using a significant portion of oil in the form of fuel oil as boiler fuel. At one time, switching the power industry to fuel oil was a progressive step, since oil was a good deal cheaper and it was more profitable to invest in developing its production. However, this situation will change substantially in the near future. If we take the adjusted cost for 1 ton of conventional fuel in the form of oil in 1975 to be 100%, then according to the branch's economic institutes this index for various types of fuel in the future will amount to:

Fuel	1975	1980	1990
Oil	100	142	180*
Gas	112	98	114
Coal (USSR average)	148	136	129
Kansk-Achinsk coal	-	54	54

* for the worst deposits: 506%

These data reveal a clear tendency: the adjusted cost for producing oil is growing very quickly; for producing gas, it is still growing slowly, but this growth will obviously accelerate in the future, while coal production expenses are constantly declining (basically due to an increase in the number of open fields). The use of oil for energy will be unprofitable compared with coal in the 11th Five-Year Plan, and even more so subsequently.

Economic factors are thus making the efficient replacement of oil in the power industry into an essential task, along with comprehensive reduction in eneergy costs and resource losses in the oil refining, petrochemical and chemical industries.

Since up to three-fourths of these branches' output is attained using catalytic processes, a very important factor in resolving the problem of the efficient use of hydrocarbon resources is the improvement of catalysts, together with an expansion and modernization of the range available. The Scientific Council for Catalysis of the State Committee for Science and Technology, in conjunction with the appropriate ministries, has developed a specific integrated program for creating and developing the production of new, highly-effective, low-temperature catalysts and expanding and modernizing their range. This program has been approved by the State Committee, Gosplan and the USSR Academy of Sciences, and provides for:

- construction of specialized catalyst production firms, whose operation will make it possible to raise their quality substantially;

- complete satisfaction of the economy's demand for catalysts, which had been initiated in the 10th Five-Year Plan;

- development and introduction of 65 new types of catalysts during the 11th Five-Year Plan;

- development of new, efficient methods of using (burning) hydrocarbon fuels for energy purposes by means of catalytic heat regenerators (CHR), whose introduction will enable a reduction in fuel consumption and in the size and complexity of equipment. The use of CHR's is especially promising for medium-temperature power production: reactant heating, heat supply, drying processes during useful ore concentration;

- development of theoretical catalysis foundations and 56 catalysts for introduction in the 12th Five-Year Plan; and

- introduction of methods for mathematical simulation of chemical reactions and optimizing their effect.

Although the main economic effect from this program's implementation will accrue from the increase in the industrial plants' product quality and productivity, the task of lowering the temperature limits of technological processes by creating new catalysts capable of operating at temperatures 100-150° lower than those now used, is no less important. Thermodynamic calculations have confirmed this possibility[5]. For example, petrochemical processes currently use an average of 1.37 tons of conventional fuel (or 1 ton of fuel oil) for processing 1 ton of raw material in producing the steam and heat required in the refining process, and 0.18 tons of conventional fuel to produce electric power. According to calculations, lowering fuel consumption by raising catalysts, selectivity and reducing the temperatures of technological processes the temperature will enable a savings of tens of millions of tons of oil annually.

It should be emphasized that this catalysis program, which has great national importance and was drawn up by more than 100 of the country's scientific institutions, will be directed and coordinated by a Siberian institute: the Catalysis Institute of the Siberian Branch of the USSR Academy of Sciences and the Scientific Council for Catalysis of the USSR Academy of Sciences, which are headed by academician G. K. Boreskov. Many of this program's important tasks will also be carried out in Siberia. For example, at the Omsk Oil Refining Plant will be organized the production of a new microspheric catalyst modified by rare earths. This catalyst, used in the catalytic cracking process, will raise the gasoline output from 30 to 38% and save a substantial amount of raw material. In the 11th Five-Year Plan, the hydrorefining plants of the Omsk and Angara oil refining plants will be switched to a new aluminonickelmolybdenum catalyst, which will raise their productivity by almost 1.5 times. Oil refining plants being built lately in Siberia are already completely designed for the new catalysts, meaning that they will also provide a substantial savings of raw material.

Hydrocarbon resource conservation is an important part of another specific integrated program, devoted to developing and mastering the production of new polymeric and composition materials. Called norplasts, these are a mixture of organic and inorganic components. A new method for filling a polymer with inorganic fillers, developed at the Institute of Chemical Physics of the USSR Academy of Sciences under the direction of academician N. S. Yenikolopov, will make it possible with the introduction of 40-50% filler to obtain materials equivalent to those made of pure polymers. Both the materials's production cost and the use of hydrocarbon raw material are almost halved. A method has also been developed for introducing filler in the amount of 90%, resulting in an excellent incombustible insulation and finishing material for construction. Whereas most of the scientific research on this program will be done by Moscow teams, the production of polyethylene, polymerization-filled by the new method, will begin at the Tomsk Chemical Plant, where the world's first plant producing such materials will be built.

The entry into operation of large-scale polypropylene and polyvinyl chloride production capacity at Siberia's chemical plants during the 11th Five-Year Plan will create very favorable conditions for the widespread use of norplasts, and their future large-capacity production will yield an economic savings calculated in hundreds of millions of rubles.

Closely associated with this group of specific integrated programs is the one for solving the scientific and technical problem of creating and mastering technological processes and integrated automatic plants providing an increase in the degree of oil refining.

It was indicated above that the use of oil for energy is becoming unprofitable. As already stated, our oil processing plants are currently producing a large amount of fuel oil which is used as boiler fuel. However, in the upcoming decade it will no longer be possible to meet the growing demand for irreplaceable petroleum products (gasoline, aircraft kerosene, diesel fuel, electrode coke, and others) by increasing the volume of oil refining, as in the past. It will therefore be necessary to develop processes for producing them from fuel oil, which in turn will be replaced at heat and electric power stations by coal.

The program calls for creation and introduction at oil refining plants of processes for refining sulfurous and high sulfur fuel oils into white products by methods of thermal and catalytic cracking, hydrocracking, carbonization and hydrorefining.

Siberian oil refining plants will also be modernized, and in some areas will become pioneers.

Many other specific integrated programs and programs for solving the most important scientific and technical problems are indirectly related to the question of efficient use of hydrocarbon resources. Those of them directly involving Siberia should also be briefly mentioned.

The program for creating and introducing new processes for low-capacity chemical product output, providing a substantial increase in the technological properties and improvement in the quality of materials, has been formulated according to economic criteria, not by branch or scientific feature. This involves chemical substances whose use in small amounts results in substantial qualitative changes in commercial products, thus yielding a significant economic savings. Very different chemical compounds can meet these requirements; therefore, the program is divided into a series of subprograms, providing for creation and industrial production of:

- new effective polymer stabilizers, including development of methods to regulate their stability;

- materials for instrument making, information equipment and biochemistry (ferro- and piezoelectrics for electronics, silver-free photographic materials, holographic information recording materials, amino acids for making synthetic protein compounds, and other materials for new, fast developing economic branches);

- additives for lubricating materials;

- new, more effective surfactants;

- new products of fine organic synthesis (paints, pigments, textile additives, chemical additives for polymers, flotation agents, and others).

Just a list of the groups of chemical compounds whose production development is envisaged by this program shows that many of them can help replenish resources and conserve hydrocarbon raw materials. In particular, these are: surfactants which enable an increase in oil pool output; stabilizers and additives which increase the durability of polymer products and thus lower the need for organic raw materials to produce polymer materials; additives to lubricate which lower their consumption standards, etc.

It should be noted that, as a rule, the organization of production of low-capacity chemical production--in particular, of fine organic synthesis products--is preceded by tests of many tens, sometimes hundreds of individual chemical compounds, of which only the best are used. It is therefore extremely important that the search for new, potentially effective fine organic synthesis products be pursued as intensively as possible in the country's scientific institutions, including those of Siberia. We already have a screening system for fine organic synthesis products, so that any basic research in this field will be useful.

The specific integrated program for creating and developing the production of new plant protection chemical agents is also primarily based on hydrocarbon raw materials. It thus operates on the same principles: assuring maximum selectivity of the synthesis process, and conserving raw materials and energy by improving the technology of these processes. It should be pointed out that certain pesticides are being created specifically for Siberia's conditions. These include oxamate, a repellant to combat blood-sucking insects, and linuron, a herbicide for soy crops. These compounds will be issued in the 11th Five-Year Plan.

The program for developing lubricant production also contains special tasks for meeting Siberia's requirements. These include the development of all-weather motor oils capable of functioning in the Far North, and production of motor oils for heavy-freight vehicles. These oils are already being used in vehicles working on BAM construction, and will be widely used in the future for auto transport on other Siberian routes.

This far from complete list of the most important tasks provided by the 1981-1985 programs describes clearly enough the growing role and importance of Siberia in the development of the essential and energy-intensive branch of the economy represented by the chemical industry.

FOOTNOTES

1. Cf: Lange, D., Oil and Gas Journ., 1978, v 76, No 5, p 119.

2. Cf: Weissermel, K., Arpe, H.-J., Industrielle Organische Chemie [Industrial Organic Chemistry], Weinheim, New York, 1976.

3. CEER, 1978, v 10, No 8, p 24.

4. X Mirovaya energeticheskaya konferentsiya [10th World Economic Conference], in the book Energetika mira [World Power Engineering], Moscow ENERGIYA [Energy], 1979.

5. Cf. Kalechits, I. V., NYEFTEKHIMIYA [Petrochemistry], 1979, No 19, p 485.

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MISCELLANEOUS

INSTALLATIONS FOR RECOVERY OF HELIUM FROM LOW-GRADE MATERIAL

Moscow VESTNIK AKADEMII NAUK SSSR in Russian No 9, Sep 80 [page numbers not provided]

[Article by I. L. Andreyev]

[Text] Thanks to its unique physical properties, helium is used widely in a number of new sectors of science and technology and, at present, the future progress of these sectors depends greatly upon the availability of an adequate supply of helium. Natural gas is the primary raw material for recovery of helium. Therefore, the establishment and rapid setting into operation of large-scale, automated installations for recovery of helium from this gas is a vital national economic problem.

Meanwhile, the helium level in gas of the Orenburg deposit is, in all, 100's of a percent while gases of most operational deposits in the world contain from 0.4 percent up to 8 percent of helium. Therefore, problems of the technology of helium recovery and the equipment set-up are much simpler abroad than they are here.

Some thought that our scientific and technical forces and our industry were unsuitable for development and construction of installations for large-scale helium recovery from such low-grade raw material as that found in Orenburg. Two American firms "Fluor" and "Airproducts", the French firm "Tekhnip" and the West Germany firm "Linde" presented proposals for the design and supply of equipment for an Orenburg gas and chemical complex. The prices, however, were prohibitive. The Americans, in spite of the fact that they have nearly 1 billion cubic meters in storage at Cliffside, demanded these incredible prices for helium.

Organization of large-scale production of helium on the basis of domestic designs and domestic equipment was proposed in a report of the director of the Sumy Machine Construction Industrial Union (SMPO) imeni M. V. Frunze, V. M. Luk'yanenko and the author of this report. In 1970, work was begun on the development of the Orenburg gas and chemical complex. Nearly 130 scientific research, drawing and design and construction and installation organizations of more than 20 ministries participated in construction of the helium plant.

Installations for producing helium concentrate constitute the basic, critical section of the helium plant. A critical factor in their operation is the condensation (liquefaction) of components of the natural gas by deep freezing for separation and recovery of the products required. In this case, there are plans for recovery, in the future, of the ethane fraction and the light hydrocarbons fractions in addition to the helium.

After a comparative workup of several alternatives, a flow chart of concentration of the helium after liquefaction of a direct flow of the natural gas by coooled refluxes of gas was selected. The gas is refrigerated by triple throttling (rarefaction). In addition to this, a propane and then a nitrogen refrigerating plant are incorporated as additional sources of cold.

After liberation of the ethane fraction, a supplemental turbo-expansion engine is engaged. The scheme has high efficiency and is protected by two inventors' certificates: "A Method For Recovery of Helium and Ethane" and "A Method For Recovery of Helium and Ethane From Law-Grade Helium-Bearing Gases."

The helium concentrate obtained contains 90-92 percent of helium as well as nitrogen, hydrogen and traces of methane. The concentrate then passes into special fine refining installations, where helium of 99.985-99.995 percent purity is recovered.

A series of installations for producing the concentrate was planned for the Orenburg helium plant. There were no installations of such capacity, which operate on low-grade gases, anywhere in the world.

Basic problems encountered in the establishment of the industrial installation for processing a large volume of gas with such low concentrations of helium involved assurance of the necessary helium recovery factor (in view of its solution in liquefied fractions of the refined raw material) and maximal reduction of energy expenditures. There was the need to solve a group of scientific and technical problems, associated with development of a flow chart and construction of equipment, methods of design of the technological process and apparatus, with the organization of new production of unique apparatus and mastery of manufacture of large, unitized apparatus and also the need to solve complex problems of installation of heavy equipment, communications and accessories under highly constrained conditions (the need for maximal compactness of disposition of apparatus to prevent cold loss) in the severe climate of the Orenburg steppe.

In this report, we can only mention the main efforts of the major contributors to the operation.

The Leningrad Scientific Research and Design Institute of Chemical Machinery developed the technological process of production of the helium concentrate and its fine refinement, made calculations for flow charts and apparatus, and developed designs of apparatus and complete units. The institute developed instructions for operation and helped to compile operational regulations, carried out the inventor's inspection during preparation, installation and start-up.

The installation designed at the Leningrad Scientific Research and Design Institute of Chemical Machinery and the apparatus incorporated into it represent a significant innovation and are protected by 12 inventors' certificates. Its refined gas productivity, provided by the design, is eight times greater than that of our largest existing installation.

We must emphasize that the increase in productivity provides the required effect only when the individual capacity of each technological link of the layout matches its overall productivity, since poor performance of one link cannot be compensated by apparatus of lower capacity operating in parallel.

This condition was predetermined by the many difficulties arising in the course of development of such large-scale units as these.

In particular, one of the most important and most complex technical problems was production of heavy pipe systems of heat exchange apparatus of units for preliminary cooling and condensation of the gas. Heat exchangers were designed with small, twisted pipes of 0.6 cm inside diameter which permit creation of an extremely large surface per unit of volume. To give an idea of the scales involved, we may say that this apparatus is 37 m high and weighs 160 tons. One heat exchanger contains 36,000 pipes with an overall length of nearly 400 km.

A basic problem in delaying production of such heat exchangers was the development of a reliable method of fastening 10's of 1000's and, in terms of the entire installation, 100's of 1000's of small pipes into the tube plates. In order that these large systems with such a relatively weak spot as the fastening of a vast number of pipes could operate successfully for a long time, it was necessary to select construction materials and methods of joining them which ensure prolonged operation at low temperature and high pressure and which withstand millions of vibration cycles. Vibration was unavoidable due to the turbulence which arises in the gas flows and the liquid-steam mixture under such high pressure at the entry of the system, as was required here. These turbulent phenomena cannot be calculated theoretically and, therefore, estimation of them requires the use of empirical methods and performance of full-scale tests (extensometering) with subsequent calculations involving the use of an electronic computer. Many new problems had to be solved in the course of installation and testing of the equipment and, in particular, the creation of new inspection procedures both in operation and in general form, including the familiar physical, mass-spectrometric and luminescence methods and new combinations of these.

The Sumy Machine Construction Industrial Union imeni M. V. Frunze, producer of the basic equipment, mastered the technology of mechanized coiling of the pipe systems of the heat exchangers with a mass of individual sections of up to 80 tons. A specialized section, at which the aggregate of complex equipment was concentrated, was created for this purpose.

The Sumy Union, in collaboration with the Leningrad NII [Scientific Research Institute] and the UkSSR Academy of Sciences Electro-Hydraulics PKB [planning and design office], developed and introduced a process of electropulsed pressing of pipes in the tube plates, which is one component of the project. The combination of high productivity and high and consistent quality of the connections made this technological process indispensable for fastening the small-diameter pipes. Specialized sections, equipped with modern electropulsed processing apparatus, were created to carry out these operations.

For production of the equipment, the union used, for the first time, cladded tube plates as envisaged by the design: these are 2-layer plates with a base high-strength layer made from ferrite-pearlite steel and the clad layer made from high-alloy austenite steel; cladding was produced by explosion. This permitted savings of much expensive high-alloy steel, while ensuring the required quality of the equipment.

Fulfillment of all of the basic organizational and technical measures, the carefully worked out welding technology, assembly and monitoring guaranteed production of high-quality equipment required for the project.

The VNIIgaz [All-Union Scientific Research Institute of Natural Gas] and the Leningrad Scientific Research and Design Institute of Chemical Machinery developed fundamental technological schemes of production and fine refinement of helium concentrate, conducted experimental studies of the properties of helium, developed a procedure for a series of theoretical and technological calculations and participated in the start-up and mastery of the installations.

The Southern Scientific Research Institute of the State Gas Industry participated in development of a technology of helium concentrate recovery, in technical solutions for construction and substantiation of its economic effectiveness and, also, in the start-up of the installation.

Simultaneously with construction of the installations, a special shop, constructed in the SMPO at the very beginning of assembly of a second installation, was designed.

The All-Union State Trust for the Installation of Oxygen Plants and Units installed the equipment, including equipment weighing up to 160 tons. The trust also prepared individual elements of metal structures--the condensation unit housing (diameter 10 m, height 40 m and weight 109 tons) and all of the piping connnection of complex, 3-dimensional configuration.

There was the need for solution of complex problems of installation technique for completing the condensation and fine refinement units, including, in particular, the pipeline of the cryogenic system.

The use of progressive methods of installation in strict conformity with network schedules, the high quality of welding operation, which promoted effective in-operation control of welding, permitted a 10-day reduction of the time for completion of testing of the world's first and USSR's first installation of this type.

"Orenburg Power Construction" was the general contractor and coordinator of all installation and construction operations and performed all construction operations.

A summary of the work is as follows.

An installation for helium concentrate production was invented. Industrial production of unique unitized apparatus was developed. The prototype installation is operating successfully, the installation of a second is being completed and construction of a third has begun.

Thus, as a result of the joint efforts of collectives of the Leningrad Scientific Research and Design Institute of Chemical Machinery, SMPO imeni M. V. Frunze, VNIIgaz, the Southern Scientific Research Institute of the State Gas Industry, the All-Union State Trust for the Installation of Oxygen Plants, "Orenburg Power Construction" and VPO [expansion unknown] of the "Orenburg Gas Industry," with the productive assistance of many other organizations and enterprises, created, in a short time, the world's first scientific, technical and industrial site with a capacity to ensure for the national economy, a helium concentrate from low-grade helium gases.

Completion of this work promoted a great increase in the technical level and the production potential of chemical machine construction enterprises.

Extensive introduction of the installations created will increase significantly the amount of helium produced in the country and this will serve as a base for development of qualitatively new sectors of science and technology.

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